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**Comparison of Vapor Sampling System
(VSS) and In Situ Vapor Sampling
(ISVS) Methods on Tanks C-107,
BY-108, and S-102**

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May 1996

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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Comparison of Vapor Sampling System (VSS) and In Situ Vapor Sampling (ISVS) Methods on Tanks C-107, BY-108, and S-102

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(a) Westinghouse Hanford Company

Executive Summary

This report discusses comparison tests for two methods of collecting vapor samples from the Hanford Site high-level radioactive waste tank headspaces. The two sampling methods compared are the truck-mounted vapor sampling system (VSS) and the cart-mounted in-situ vapor sampling (ISVS). Three tanks were sampled by both the VSS and ISVS methods from the same access risers within the same 8-hour period. These Tanks (C-107, BY-108, and S-102) were selected because their headspace compositions are diverse, and they represent the highest known levels of several key vapor analytes. Samples were collected from all three tanks in January 1996, when ambient temperatures were at or below freezing. This ensured a test of the ISVS method during one of the most adverse field conditions.

The primary criterion used to decide that the VSS and the ISVS methods are comparable is that the relative percent difference between the results obtained for a specific analyte by both methods does not exceed 30 percent. This criterion evaluates whether or not the difference is significant to data users. The value of 30 percent is derived from the expected accuracy of the laboratory analysis system. The second criterion is a statistical comparison of the mean values from the VSS sampling methods with the mean value of the ISVS method (two sample t test). This second test evaluates the "data scatter" from each sampling method and then compares the difference of the mean values of the two sampling methods with the range of values (scatter) from each method. If the difference of the means is less than the data scatter from the individual sampling methods, then the methods can be considered to be comparable. Passing either criterion indicates that the two sample methods are comparable for that particular analyte. Only data that are within the quantitation range of the analytical measurement methods are used for the comparisons.

Results from the two comparison criteria indicate that the ISVS method is essentially equivalent to the VSS method. Of 65 comparisons, 56 (86 percent) passed the acceptance criteria. The three dominant vapor space waste constituents (i.e., ammonia, hydrogen, and nitrous oxide) are among those passing the acceptance criteria with sample results very close to the VSS method. Gases and vapors that met the acceptance criteria in all tanks include ammonia, water vapor, and the permanent gases. Relative percent differences between the sample method means ranged, for ammonia and water vapor, between three and eight percent, and for the permanent gases from 0.3 to 2 percent. Total nonmethane hydrocarbon results also met the criteria, except for samples from Tank C-107, where contamination from adhesive tape used to seal the sample tube bundle caused results outside the acceptance criteria. An alternate sealing method has since been developed. Most of the organic vapors collected by SUMMA™ canister also met the comparison criteria. Of those organic vapors outside the acceptance criteria (five of 29), two semivolatile organic vapors experienced low transfer to the sample canister through unheated tubing on a very cold day, and three demonstrated no trend toward lower or higher concentrations than the VSS sample method (i.e., no consistent bias). Most organic vapors collected by triple sorbent traps (TSTs) also met the acceptance criteria. Seven of 20 results exceeded the acceptance criteria, but also demonstrated no trend toward lower or higher concentrations than the VSS method (i.e., no consistent bias). Those organic vapor results outside the acceptance criteria collected

by either ISVS TSTs or ISVS SUMMA™ canisters were considered acceptable since the difference between VSS TST and VSS SUMMA™ canister sample results were generally greater than the differences between the VSS and ISVS methods.

As was anticipated, certain semivolatile organic vapors in Tank BY-108 were not quantitatively transferred through the ISVS transfer tubing to SUMMA™ canister samples. Future analyses of semivolatile organic vapors in SUMMA™ canisters collected by the ISVS method should thus be considered suspect if their concentrations are very high, as was the case in Tank BY-108. In such situations, either the semivolatiles should be measured using the TST samples, or the VSS should be used to collect SUMMA™ canister samples.

Table S.1 provides summary results of the VSS and ISVS (without particle filter) comparison tabulated by vapor type. The second and third columns in Table S.1 give the number of results indicating the VSS and ISVS methods to be equivalent based on the relative difference and two sample t test, respectively. The last column gives the number of results, which indicate the VSS and ISVS methods to be different according to both criteria.

Tests of the ISVS system with and without a particulate filter were conducted to assess the removal of tributyl phosphate and other semivolatile organic vapors by the filters. The filters are necessary in the VSS method to prevent contamination of the sampling system, but can be eliminated in the ISVS method because of the ease of system decontamination. Results indicated that the filters did adversely affect the collection of low volatility organic vapors; however, because tributyl phosphate was not detected in any of the samples (filtered or unfiltered), the effect of the filters on tributyl phosphate could not be determined. Because of the effect on low volatility organic vapors, the ISVS samples without the particulate filter are used in the comparison study. Future production sampling should be conducted without the filters.

**Table S.1. Summary of Statistical Comparisons between VSS and ISVS
(without particle filter)**

Analytes	Results with Relative Percent Difference < 30 %	Results with t Test Significance Level > 0.05	Results Not Meeting Either Criteria
Permanent Gases (7 results for H ₂ , N ₂ O, CO ₂)	7	5	0
Inorganic Vapors (6 results for NH ₃ , H ₂ O)	6	1	0
Total Nonmethane Hydrocarbon Vapors (3 results)	2	0	1
Organic Vapors (49 results for 18 compounds)	40	37	8
Total (65 results)	55	43	9

Terms and Abbreviations

E	flag for result exceeding upper calibration limit
EQL	estimated quantitation limit
FID	flame ionization detector
GC	gas chromatograph
GC/MS	gas chromatograph-mass spectrometer
IDL	instrument detection limit
IDLH	immediately dangerous to life or health
ISVS	in situ vapor sampling
J	flag for result between instrument detection limit and estimated quantitation limit
NIOSH	National Institute for Occupational Safety and Health
PNNL	Pacific Northwest National Laboratory
RPD	relative percent difference
S	flag for suspect result
SAP	sampling and analysis plan
SUMMA™	Trademark of Molectrics, Inc., for surface pacification process
TAP	toxic air pollutant
TNMHC	total nonmethane hydrocarbon
TST	triple sorbent trap
U	flag for result below instrument detection limit
UCL	upper calibration limit
VSS	vapor sampling system
WHC	Westinghouse Hanford Company

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1.0 Introduction

1.1 Objective

The objective of this report is to evaluate the equivalency of two methods used to sample nonradioactive gases and vapors in the Hanford Site high-level waste tank headspaces. In addition to the comparison of the two sampling methods, the effects of an in-line fine particle filter on sampling results are also examined to determine whether results are adversely affected by its presence.

1.2 Scope

This report discusses data from the January 1996 comparison of two methods used to sample gases and vapors in the waste tank headspaces. A statistical evaluation of results is presented, and the equivalency of the sampling methods is discussed in terms of the data requirements. Overviews of the sampling methods and events, and analytical procedures and results are given here. These are described in more detail in separate reports (i.e., WHC 1996a-f). Logistical and financial differences between the sampling methods are not addressed in detail.

1.3 Background

The waste tank headspaces are being characterized for tank safety, industrial hygiene, and regulatory air emissions purposes. Characterization is accomplished by sampling the headspace air with whole-air samplers (i.e., SUMMA™ passivated stainless steel canisters) and sorbent trap sampling devices, which are then sent to analytical laboratories for analyses. Two types of equipment and methodologies are available for filling or exposing these sampling devices to tank headspace air. Most of the characterization performed to-date has been accomplished using the vapor sampling system (VSS). The other sample collection method, the in situ vapor sampling (ISVS) method, was recently upgraded to improve sample volume flow measurement equipment.

The VSS was designed for the collection of large numbers of samples from tanks having high headspace temperatures and high vapor concentrations. Though it has been used to characterize over 60 tanks, it was specifically designed for an in-depth study of Tank C-103, a hot, humid tank with very high levels of organic vapors. The VSS has proven to be a very reliable tool for sample collection; however, duplication of the VSS would be costly, its sampling rate is slow and manpower needs are intensive. The ISVS system, by comparison, has been designed to collect a standard number of samples and uses relatively simple equipment that can easily be duplicated.

Each method has certain logistical, financial, and technical advantages, depending on the characterization needs. For characterization of the remaining tanks to meet safety screening, industrial hygiene, and regulatory needs, the ISVS method appears to provide an adequate number of samples at

a much lower cost than the VSS method. This comparison study of the two methods has been designed to determine if the quality of samples obtained by the ISVS method is comparable to that of the VSS.

Comparison tests were also conducted to examine the effects of glass fiber particle filters that have been used to remove radiological particles from the sample stream in the VSS. In laboratory tests in which sample air was passed through these filters, an important semivolatile constituent (tributyl phosphate) was removed by the filters (Jenkins et al. 1995), and there has been concern that the filters adversely affected the measurement of other constituents. Because the particle filters are optional in the ISVS method, it was possible in this study to collect sets of samples with and without the filters, allowing a direct evaluation of the effects of the filters.

1.4 Comparison Criteria

Two criteria were used to compare the results from the VSS and the ISVS methods, and to compare the results from the ISVS method with and without the particle filter. Both criteria involve a comparison of result means. The result means from the VSS and ISVS methods provide estimates of the concentration of each gas and vapor in the tank headspace. This study tests the equivalence of these estimates.

The first criterion required that differences between the vapor sampling system (VSS) and in situ vapor sampling (ISVS) methods be significant to data users. This criterion was based on guidelines given by the sampling and analysis plan (SAP), which specifies vapor sampling results be within 30 percent of their true values (Homi 1996). The 30 percent accuracy requirement was based on advice from members of the Tank Vapor Conference Committee as a reasonable goal for the error associated with sample analysis and is consistent with safety and regulatory requirements on similar measurements of mixed waste by the U.S. Department of Energy (DOE 1996), and U.S. Environmental Protection Agency (EPA) guidelines for comparable analytical methods (EPA 1994). For the purposes of this comparison study, the VSS results will be assumed to represent the true concentration of each analyte. Mathematically, if the absolute value of the difference between mean ISVS and VSS concentrations is less than 30 percent of the VSS result, then the ISVS method will be considered to be equivalent to the VSS method.

The second criterion is a statistical comparison of means from the VSS and ISVS sampling methods and a comparison for the ISVS sampling method with and without the particle filter. For each tank and analyte, a two sample t test was used to determine whether differences between the result means were statistically distinguishable (at the 0.05 level of significance). A description of the two sample t test can be found in Snedecor and Cochran (1980).

To compare the VSS and ISVS results, a t-statistic was computed and compared with a tabulated quantile (two-tailed test) from the t-distribution. The t-statistic is the absolute value of the difference between the means of the VSS and the ISVS observations divided by the estimated standard deviation of the difference between the means. The significance level is 0.05 (two-tailed test), and the number of degrees of freedom is the total number of observations minus two.

The statistical criterion for stating equivalence of the VSS and ISVS sampling methods is that the means of the VSS and ISVS methods cannot be distinguished from each other (0.05 level of significance). This comparison criterion was required in *Sampling and Analysis Plan for Tank Vapor Sampling Comparison Test* (SAP) (Homi 1996).

It is important to note that the VSS and ISVS methods are indicated to be different in a meaningful way only when the magnitude of differences has consequences to the data users, and the results from the two methods are statistically significantly different. Essentially, the relative difference test indicates whether the observed differences are as large as the acceptable measurement errors, and the t test indicates whether the observed differences are statistically significant (and not simply random).

1.5 Selection of Study Tanks

Tanks BY-108, C-107, and S-102 were selected as the subjects of this study. A partial list of the parameters considered in the selection of these tanks is given in Table 1.1. These tanks were selected for their diverse headspace compositions so that, to the extent possible, the observations from this subset of tanks can be used as indicators of the behavior of other tanks. Among all the tanks that have been characterized, these tanks contain high levels of several important constituents, namely hydrogen, nitrous oxide, ammonia, water vapor, carbon dioxide, and semivolatile organic vapors.

Tank C-107 is a hot sludge tank with very high humidity and relatively low concentrations of organic vapors and the three principal waste gases (i.e., hydrogen, ammonia, and nitrous oxide). Tank BY-108 has the highest concentration of ammonia of any tank that has been sampled and the second highest total organic vapor concentration. Tank S-102 has primarily saltcake waste, relatively high hydrogen and nitrous oxide concentrations, and moderate levels of organic vapors. Tank S-102 was also chosen in part as representative of 200 West farm tanks, which tend to have a higher proportion of volatile alcohols.

Headspace concentrations given for Tank BY-108 in Table 1.1 were measured in October 1994. In August 1995, use of an exhauster on Tank BY-108 (during rotary mode core drilling operations) effectively reduced its headspace composition to near-ambient levels. When the tank was resampled in January 1996, the headspace concentrations were observed to be markedly lower than they had been in October 1994. This is apparently due to the use of the exhauster in August 1995, despite an approximately five month period between the last use of the exhauster and the sampling event in January 1996. Though worth noting here, this unexpected observation did not affect the use of the sampling data from Tank BY-108.

Table 1.1. Selection Criteria for Study Tanks

	BY-108^(a)	C-107^(b)	S-102^(c)
Waste^(d)			
Sludge volume	154 kgal	237 kgal	4 kgal
Saltcake volume	74 kgal	0 kgal	545 kgal
Supernate volume	0 kgal	0 kgal	0 kgal
Total waste volume	228 kgal	237 kgal	549 kgal
Headspace			
Volume	3,118 m ³	2,342 m ³	1,918 m ³
Temperature	25.7 °C	45.9 °C	24.3 °C
Relative humidity	56 %	86 %	63 %
Hydrogen	399 ppmv	< 80 ppmv	669 ppmv
Nitrous oxide	641 ppmv	41 ppmv	509 ppmv
Ammonia	1,040 ppmv	84 ppmv	412 ppmv
Carbon dioxide	224 ppmv	654 ppmv	< 64 ppmv
Total organic vapors ^(e)	510 mg/m ³	3.7 mg/m ³	9.4 mg/m ³
Notes:	NPH and ammonia vapors very high	Carbon dioxide above ambient, very hot & wet	Alcohol vapors very high, high hydrogen
<p>(a) Tank BY-108 was sampled October 27, 1994. Headspace data are from Huckaby and Bratzel (1995a).</p> <p>(b) Tank C-107 was sampled September 29, 1994. Headspace data are from Huckaby and Bratzel (1995b).</p> <p>(c) Tank S-102 was sampled March 14, 1995. Headspace data are from Huckaby and Bratzel (1995c).</p> <p>(d) Waste volumes are from Hanlon (1996).</p> <p>(e) Total organic vapor concentration values are from summation of individual constituents in triple sorbent traps analyzed by Oak Ridge National Laboratory (Huckaby and Bratzel 1995a, b, c).</p>			

2.0 Sample Collection

2.1 Vapor Sampling System

The VSS consists of a mobile laboratory, a hot-water-jacketed stainless steel probe that is inserted into the tank headspace, and stainless steel transfer tubing that connects the mobile laboratory with the probe. Sample air is drawn from the tank headspace and through the transfer tubing and sampling manifold by an air pump. Air flow within the VSS is directed by electrically activated, pneumatically actuated valves. Instrumentation housed in the mobile laboratory provides the means to monitor and control system temperature, monitor absolute and differential system pressure, meter and control mass flow, and monitor hydrocarbon vapor concentrations. Mahon et al. (1994) describe the VSS performance and operation in detail.

A key feature of the VSS is the use of heated sample transfer tubing and a heated sampling manifold. Maintaining the system temperature at an electronically controlled, elevated temperature prevents vapor condensation and reduces vapor adsorption on surfaces exposed to sample air. Mahon et al. (1994) describe various tests and observations that indicate the VSS sample transfer efficiency is consistently high.

Sorbent trap samples are collected at the sorbent trap station of the sampling manifold. High accuracy mass flow controllers are used to measure and control the flow rate of sample air through the sorbent traps. These are located downstream of the sorbent trap station and downstream of in-line dryers that remove water vapor from the air before it is metered. The sorbent trap station allows collection of 9 samples simultaneously, and most sorbent trap samples of a given type are collected simultaneously in sets.

The VSS sampling manifold also has a station for sampling air with evacuated SUMMA™ canisters. To prevent condensation and minimize adsorption of vapors during SUMMA™ canister sampling, the connection tubing between the sampling manifold and the canister itself, as well as the mechanical valve on the SUMMA™, are heated with electrical heat tape.

The VSS is cleaned according to standard operational procedures before use (WHC 1996a). A gas chromatograph (GC) with a flame ionization detector (FID) is used to confirm that the VSS is free of hydrocarbons to its limit of detection. The GC/FID is part of the VSS and may be used periodically throughout a sampling event to monitor organic vapor concentrations in the air being sampled.

2.2 In Situ Vapor Sampling System

The ISVS method uses an alternative approach to sample collection. Rather than transferring the air, gases, and vapors to be sampled to a remote location, the sampling devices themselves (specifically, sorbent traps) are lowered into the headspace of the tank. This minimizes the loss of constituents

by adsorption on transfer tubing walls and circumvents the need for heated probes, heated transfer tubing, and a heated sampling manifold. The ISVS equipment consists of a simple manifold and air pump mounted on a two-wheel handcart. Small bundles of sorbent traps are lowered into the tank headspace; each sorbent trap has its own 0.64-cm (0.25-in.) diameter plastic tube connection to the sampling manifold. The current sampling manifold is capable of collecting four samples simultaneously using needle valves to control flowrates, electronic mass flow meters to monitor flowrates, and electronic totalizers to integrate total sample volumes.

In the ISVS method, constituents that are not amenable to sorbent trap sampling (e.g., gases such as hydrogen, nitrous oxide, and methane) are sampled using an unheated Teflon® tube that transfers sample from the headspace to whole air sampling devices (i.e., SUMMA™ canisters) located outside the tank. Loss of these constituents from the sample by adsorption on transfer tubing walls is minimized by purging the transfer tubing with sample air before the sample is collected. Though condensation of water vapor may occur in the unheated plastic transfer tubing, the primary analytes of whole air samples are sparingly soluble in water, and consequently, should not be affected strongly. ISVS cleaning requirements are minimal because transfer tubing for whole air samples is disposable.

2.3 Sampling Events

The ISVS and VSS method sampling of Tanks C-107, BY-108, and S-102 is discussed in six separate reports (WHC 1996a-f). Each tank and sampling method is documented separately. Only a summary is presented here. Information common to all three tank sampling events is presented in this section, and tank-specific information is presented in the following subsections.

The ISVS and VSS samples were collected from approximately the same elevation within the headspace using the same tank access riser. All samples from a given tank were collected within the same working day, and sample collection by ISVS and VSS was initiated at about the same time to reduce any differences associated with temporal variations in the sampling. However, because a double set of samples were collected with the ISVS method (i.e., one set with particle filtration and one set without particle filtration) and the ISVS method had not been used in its new configuration before, the ISVS events required more time than the VSS events.

ISVS method samples were collected in three separate bundles designated bundle A, bundle B, and bundle C. Bundles A and B contained particle filters upstream of the sorbent traps, bundle C did not. Two bundles (i.e., A and B) were required for the filtered samples because the available sample bundle heads had only nine sample ports. The particle filter housings of bundles A and B were preheated before being lowered into the tank to prevent condensation of water vapor on the filters and tubing. Two thermocouples attached to the housings of bundles A and B indicated that the housings were indeed above the dew point temperature of each tank headspace at the onset of sampling, and condensation should have been minimal.

The ISVS sample bundles were lowered into the tank headspace and removed sequentially and were not present in the headspace at the same time. Tiny droplets of condensate, presumed to be water,

formed inside the unheated SUMMA™ sampling tubing where it exited the tanks. Condensation of water vapor was expected in this region because ambient temperatures at the time of sampling were significantly below the tank dew point temperatures. Other sampling anomalies are described in the sampling reports (WHC 1996a-f), and the potential effects of these anomalies on results are discussed in Section 5.0.

2.3.1 Tank C-107

Vapor samples were collected from Tank C-107 by the VSS and ISVS methods on January 17, 1996. Table A.1 in the Appendix lists the identification numbers of all headspace samples collected. Tank headspace samples were collected using the VSS between 12:21 and 1:33 p.m. ISVS bundle A samples were collected between 12:19 and 12:54 p.m., bundle B samples were collected between 1:39 and 2:19 p.m., and bundle C samples were collected between 2:50 and 4:01 p.m. Ambient temperatures during the sampling of Tank C-107 ranged from about -3 to 3°C. Details of the sampling event are documented in WHC 1996a.

2.3.2 Tank BY-108

Vapor samples were collected from Tank BY-108 by the VSS and ISVS methods on January 23, 1996. Table A.2 in the Appendix lists the identification numbers of all headspace samples collected. Fewer triple sorbent trap (TST) samples were analyzed than planned because 1 TST was accidentally broken while dismantling bundle C, and another TST, also from bundle C, was broken in the laboratory before analysis.

Tank headspace samples were collected using the VSS between 12:08 and 1:00 p.m. ISVS bundle A samples were collected between 11:12 and 11:52 p.m., bundle B samples were collected between 12:25 and 1:06 p.m., and bundle C samples were collected between 2:07 and 3:16 p.m. Ambient temperatures during the sampling of Tank BY-108 ranged from about -6 to -2°C. Details of the sampling event are documented in WHC 1996b.

2.3.3 Tank S-102

Vapor samples were collected from Tank S-102 by the VSS and ISVS methods on January 26, 1996. Table A.3 in the Appendix lists the identification numbers of all headspace samples collected. Because recent core sampling activities at Tank S-102 had raised questions about possible changes in the headspace composition during the vapor sampling events, two extra SUMMA™ canisters were collected using the VSS (S6007-A87.086 and S6007-A88.089). These were collected after the ISVS bundles B and C were completed. The data (i.e., Tables 3.3, 3.9, and 3.12) indicate that these two extra samples are very similar to those taken earlier, and no changes in headspace composition appear to have occurred.

Tank headspace samples were collected using the VSS between 10:40 a.m. and 2:52 p.m. ISVS bundle A samples were collected between 10:37 and 11:18 p.m., bundle B samples were collected

between 11:50 and 12:31 p.m., and bundle C samples were collected between 1:18 and 2:36 p.m. Ambient temperatures during the sampling of Tank S-102 ranged from about -5 to -7°C. Details of the sampling event are documented in WHC 1996c.

3.0 Sample Analysis and Analytical Results

3.1 Quality Assurance

Samples were analyzed in accordance with *Hanford Analytical Services Quality Assurance Plan* (DOE 1995), *Quality Assurance Project Plan for Tank Vapor Characterization* (Keller 1994), and *Quality Assurance Plan for Activities Conducted by the Pacific Northwest National Laboratory Vapor Analytical Laboratory (VAL) and the Pacific Northwest National Laboratory Tank Vapor Characterization Project* (PNL 1995). Deviations from these plans are documented in the individual analytical reports (Thomas et al. 1996, Pool et al. 1996, Evans et al. 1996).

3.2 Analyses and Results

The number of samples and certain aspects of the sequence in which they were analyzed were specified in the SAP (Homi 1996). For each tank and each type of sampling device, six samples were collected using the VSS, six samples were collected using the ISVS with particle filtration, and six samples were collected using the ISVS without particle filtration. The sequence by which the resulting 18 samples were analyzed was then chosen to minimize analytical bias. Analysis dates and other specifics are given in the individual analytical reports (Thomas et al. 1996; Pool et al. 1996; Evans et al. 1996).

Table 3.1 lists the analytes for this comparison study, along with the analytical detection and quantitation limits for each analyte. Analytical results between the estimated quantitation limit (EQL) and the upper calibration limit (UCL) are referred to as quantitative; results outside this range are measured with less confidence. Note the instrument detection limit (IDL) is one tenth the EQL. The UCLs listed are for standard sample aliquots, and for most analytes can be increased by changing sample aliquot size or diluting the aliquots.

3.2.1 Ammonia and Water Vapor

Ammonia analyses were conducted on acidified carbon bead sorbent trap samples. Ammonia was removed from the sorbent media by liquid extraction and analyzed by an ion-specific electrode. Quality control objectives were achieved using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and field samples were analyzed for comparative purposes.

Water vapor was measured by a gravimetric method. Water vapor was collected by the hygroscopic ammonia sorbent traps and two silica gel sorbent traps connected in series behind the ammonia sorbent trap. Each sorbent trap was accurately weighed before and after sample collection,

Table 3.1. Analytical Detection and Quantitation Limits

Analyte	Units	Instrument Detection Limit (IDL)		Estimated Quantitation Limit (EQL)		Upper Calibration Limit (UCL) ^(a,b)	
Ammonia	ppmv	0.7		6.7		6700	
Water Vapor	mg/L	0.05		1		N/A ^(c)	
Hydrogen	ppmv	4		31		2115	
Nitrous Oxide	ppmv	2		20		2107	
Carbon Dioxide	ppmv	3		24		2103	
Carbon Monoxide	ppmv	4		32		2141	
Methane	ppmv	5		43		2111	
TNMHC Vapors	mg/m ³	0.082		0.82		1600	
		SUMMA™	TST	SUMMA™	TST	SUMMA™	TST
Methanol ^(d)	ppbv	N/A	19	N/A	190	N/A	2300
Ethanol ^(d)	ppbv	N/A	13	N/A	134	N/A	1606
1-Propanol	ppbv	0.5	2.1	5.0	21	900	1198
1-Butanol	ppbv	0.5	2.3	4.8	23	881	1173
Acetonitrile	ppbv	1.1	1.9	10.9	19	1502	2005
Propanenitrile	ppbv	0.8	0.8	7.7	8.1	1222	1629
Acetone	ppbv	0.7	2.7	7.0	27	1147	1529
2-Butanone	ppbv	0.4	0.6	4.4	6.2	1061	1414
Tetrahydrofuran	ppbv	0.2	0.3	2.5	3.1	681	824
Hexane	ppbv	0.4	0.4	4.2	3.9	732	977
Nonane	ppbv	0.2	0.3	1.6	2.6	317	423
Decane	ppbv	0.2	0.5	2.4	4.7	510	680
Undecane	ppbv	0.2	0.6	1.9	6.5	304	406
Dodecane	ppbv	0.6	3.4	6.5	34	344	458
Tridecane	ppbv	0.4	6.6	3.7	66	285	379
Tetradecane	ppbv	0.2	1.5	2.4	15	193	258
Tributyl phosphate ^(d)	ppbv	N/A	0.8	N/A	8	N/A	800

(a) UCL for ammonia can be increased by dilution of sample extract.
(b) UCL for hydrogen, nitrous oxide, carbon dioxide, carbon monoxide, methane, TNMHC vapors, and all SUMMA™ canister organic vapor analytes can be increased by reducing sample aliquot and/or by diluting the sample.
(c) UCL for water vapor measurements are not meaningful because sorbent trap water capacity is lower than the upper instrument calibration limit.
(d) EQL for methanol, ethanol, and tributyl phosphate in TSTs are based on the lower calibration standard; the IDL for these compounds is 0.1 times the EQL.

and the difference in weights was assumed to be due to collected water vapor (all other condensable constituents are negligible). Quality control objectives were achieved by balance calibration, the use of standard weights, and use of field and trip blanks.

Ammonia and water vapor results for Tanks C-107, BY-108, and S-102 are given in Appendix Tables A.4, A.5, and A.6, respectively. Three observations were excluded from the means and percent relative standard deviations given in the tables, as indicated with brackets in Tables A.4 and A.5. These were deemed by the analyst to be analytical outliers.

To minimize analytical biases, all ammonia sorbent traps from the three different sampling modes of a given tank (i.e., VSS, ISVS with particle filtration, and ISVS without particle filtration) were analyzed on the same day in a randomized sequence.

3.2.2 Permanent Gases

The permanent gases analyzed in tank vapor headspace samples included hydrogen, carbon dioxide, carbon monoxide, methane and nitrous oxide. The method was based on samples collected in SUMMA™ canisters. Aliquots of the collected vapor were analyzed using a gas chromatograph coupled with a thermal conductivity detector (GC/TCD). The analytes were identified by matching the sample peak retention time with that of a traceable gas standard mixture. The same standard mixture was used to calibrate the method for quantitation. Quality control objectives were achieved using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and ambient air samples taken in the tank farm were analyzed for comparative purposes.

Permanent gas results for Tanks C-107, BY-108, and S-102 are given in Appendix Tables A.7, A.8, and A.9, respectively. All SUMMA™ canister samples from the three different sampling modes of a given tank were analyzed on the same day.

3.2.3 Total Nonmethane Hydrocarbon Vapors

An analysis for total hydrocarbon compounds (excluding methane) present in the tank headspace vapor samples was performed. The method was based on Environmental Protection Agency (EPA) procedure TO-12 for total nonmethane hydrocarbon (TNMHC) vapors in ambient air samples. The method was applied to samples collected in SUMMA™ canisters. The TNMHC vapors were pumped through a cryogenic concentrator and then analyzed using an FID. Quantitation was achieved using a multiconcentration calibration curve generated using a traceable propane standard of known concentration. Quality control objectives were achieved using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and ambient air samples taken in the tank farm were analyzed for comparative purposes.

The TNMHC vapor results for Tanks C-107, BY-108, and S-102 are given in Appendix Tables A.10, A.11, and A.12, respectively. All SUMMA™ canister samples from the three different sampling modes of a given tank were analyzed on the same day.

3.2.4 Organic Vapors in SUMMA™ Canisters

Analysis of organic vapors in SUMMA™ canisters was based on EPA procedure TO-14 for speciating organic vapors in ambient air samples, but has been modified for use on tank headspace samples. Tank headspace samples typically have higher concentrations and constituents with a wider variety of physical and chemical properties than found in ambient samples. The tank headspace vapor samples were pumped through a cryogenic concentrator and then analyzed using a gas chromatograph-mass spectrometer (GC/MS). Quantitation was achieved using two methods. One was the use of a traceable TO-14 standard containing 39 compounds of known concentration. Calibration for tank headspace constituents not found in commercially available TO-14 standards was achieved using gas standards prepared from calibrated permeation tubes. Quality control objectives were achieved using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and ambient air samples taken in the tank farm were analyzed for comparative purposes.

Organic vapor results from SUMMA™ canister samples for Tanks C-107, BY-108, and S-102 are given in Appendix Tables A.13, A.14, and A.15, respectively. Samples from the three different sampling modes of a given tank were analyzed in a randomized sequence intended to reduce any analytical bias. However, only about six analyses could be performed during a 12-hour analytical run, and occasionally, specific analyses within the run failed quality control criteria.

3.2.5 Organic Vapors in Triple Sorbent Traps

Analysis of organic vapors was also performed on commercially produced graphitized carbon TSTs. The volatile organic compounds adsorbed on the traps were thermally desorbed from the traps and analyzed using a GC/MS. Quantitation was achieved using the same two methods as used for SUMMA™ canister organic vapor analysis. Quality control objectives were achieved using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and ambient air samples taken in the tank farm were analyzed for comparative purposes.

Organic vapor results from TSTs for Tanks C-107, BY-108, and S-102 were given in Appendix Tables A.16, A.17, and A.18, respectively. Two TSTs were broken in the Tank BY-108 ISVS set without particle filtration (one in the field when the bundle was dismantled and one in the laboratory before analysis). Additionally, one TST in the Tank BY-108 ISVS set without particle filtration (sample S6005-A39.731) was deemed suspect by the analyst and was excluded from the calculated means.

TSTs from the three different sampling modes of a given tank were analyzed in a randomized sequence intended to reduce any analytical bias. Though not apparently significant, the randomization was compromised because of limitations on the number of successful analyses that could be performed during each analytical run.

3.3 Anomalous Results

3.3.1 Blank Contaminants

All TST samples from Tanks C-107 and BY-108 (VSS, ISVS, field and trip blanks) contained moderately high and variable amounts of 1-chloro-1,1-difluoroethane (Freon 142b). This compound has appeared persistently in all samples sent to the field through January 23, 1996. It is believed to be a fugitive refrigerant. TSTs archived for a similar amount of time in the 326 Vapor Laboratory or 329 Building temporary storage are not contaminated by this compound. The origin of the material is unclear, but since it has appeared in trip blanks as well as field blanks, it is possibly from a refrigerator used for sample storage before or after sampling. It is worth noting, however, that the contaminant was not seen in the Tank S-102 samples, suggesting that either some change in sample storage protocol occurred or the leak has been fixed (or the source exhausted) between the Tank BY-108 and S-102 sampling events.

In addition to the fluorocarbon problem, a more serious blank problem was seen in all samples and field blanks exposed to the ISVS sampling head. The compounds included, but were not limited to, methanol, 1-butanol, hexane, heptane, methyl hexane, and methyl cyclohexane. The source of the problem was traced to the use of plastic adhesive tape (3M Scotch Brand 471) to bind the ISVS bundles during insertion into the tank. The adhesive material on this tape is clearly a major source of volatile organic compounds. Analysis of a piece of the tape from the same roll used for the sampling job confirmed this supposition. A clean TST was exposed to the tape adhesive for one hour and analyzed by standard protocols during routine analysis of Tank C-107 samples. The resulting chromatogram and mass spectral identification showed a good pattern match to many of the compounds seen at similarly high levels in the ISVS samples from Tanks C-107, BY-108, and S-102. Of special interest were hexane and 1-butanol, which were subject analytes of this study and present at relatively high concentrations in the tape.

Contamination from the tape was most evident in TSTs from Tank C-107, in part because Tank C-107 has very low levels of hexane and 1-butanol, and the contamination was significant. SUMMA™ canister samples appear to have been affected to a lesser degree. A similar tape contamination problem was observed in ISVS results from Tank S-102, but any contamination of Tank BY-108 samples was apparently insignificant compared to the levels of hexane and 1-butanol in the tank.

3.3.2 Passive Sampling

Since sorbent traps in the ISVS method are physically exposed to the tank vapor for some time before and again after actual sample collection, some amount of passive sampling by diffusion of

vapors to the sorbent media is to be expected. (SUMMA™ canister samples are not affected by passive sampling.) To estimate the impact of passive sampling, field blanks are included in the ISVS bundle. The field blanks are physically configured identically to other samples, but no sample air is drawn through them. Field blank data were used by the analysts to correct both the ammonia and water vapor measurements. Unfortunately, because the TST field blanks were also contaminated by emissions from the ISVS bundle tape, quantitatively correcting the TST results for the effects of passive sampling was not deemed appropriate.

The impact of passive sampling increases with the length of time the samples remain in the headspace, and as the sorbent trap sample volume decreases. For ammonia sorbent traps, which used nominal 2-L sample volumes, the field blank correction amounted to as much as five percent in Tank BY-108, where the ISVS bundles remained in the tank the longest period. For TSTs, which used relatively small 0.2-L nominal sample volumes, field blanks were found to have as much as 10 to 20 percent of the material present on the 0.2-L samples (Pool et al. 1996).

The effects of passive sampling in the ISVS method can be reduced by 1) limiting the time that samples are actually present in the headspace and 2) collecting samples in a sequence designed to minimize the impact of passive sampling.

3.3.3 Apparent System Leaks

There was evidence that there may have been a small leak in the transfer tubing used to fill SUMMA™ canisters in the ISVS method. Specifically, SUMMA™ samples collected using the ISVS method from Tank S-102 appear to have been diluted with ambient air. There was also some indication of a very small leak in the Tank BY-108 ISVS method SUMMA™ samples. However, the most compelling evidence for a leak comes from the permanent gas results for Tank S-102. In Appendix Table A.9, the carbon dioxide concentration was clearly highest in the filtered ISVS method samples and higher in the unfiltered ISVS method samples than in the VSS samples. An explanation for this observation is that connections at either end of the Teflon® transfer tubing used to fill the SUMMA™ canisters were not well sealed. Ambient air, which normally contains 350 to 400 parts per million by volume (ppmv) of carbon dioxide, may have leaked into the transfer tubing when the SUMMA™ canister was opened, introducing measurable amounts of carbon dioxide to the sample. Supposing that the air leaking in contained 408 ppmv of carbon dioxide (the average of four ambient air samples collected at Tank S-102), and that the level of carbon dioxide in the tank air was effectively 0 ppmv, the mean 33 ppmv of carbon dioxide in filtered ISVS method samples would indicate that about 8 percent of the SUMMA™ sample was ambient air.

Analogous results for hydrogen and nitrous oxide support the conclusion that the Tank S-102 filtered ISVS method SUMMA™ samples were diluted with ambient air. These gases, which are not present in ambient air at significant concentrations, were measured at lower levels in the filtered ISVS method samples than in the VSS samples. Because hydrogen and nitrous oxide concentrations in ambient air are effectively 0 ppmv, the measured concentrations of these gases suggest the SUMMA™ samples were diluted about 7 percent with ambient air.

The apparent cause of the leak, an improper connection between the stiff Teflon® transfer tubing and ports at either end, should not occur in future ISVS events because a different type of tubing is to be used. The effects of this type of leak are also evident in the Tank BY-108 SUMMA™ samples, whereas in Tank S-102 the problem is worse for the filtered ISVS method than for the unfiltered ISVS method. In general, the dilution of the SUMMA™ samples was small compared to the allowed 30 percent relative difference in the sampling methods.

4.0 Data Analysis

4.1 Data Selection

In addition to the comparison criteria described in Section 1.4, the SAP requires that analytical results used for the comparison of the sampling methods be within the instrumental quantitation limits (Homi 1996). This is to ensure that, to the extent possible, differences between the results can be attributed to sample method differences and not analytical differences. Table 4.1 summarizes the quantitation status of all the available analytical results. Results marked as "valid" were considered for the purposes of this study to be quantitative. Results in Table 4.1 are marked with a "U" if the analyte was essentially not detected, i.e., below the instrument detection limit; a "J" if the results are primarily estimated, i.e., between the instrument detection limit and the lower quantitation limit; an "S" if the data are clearly suspect, e.g., 1-butanol and hexane were strongly associated with tape off-gassing in the ISVS results; or an "E" if the results exceeded the upper end of the instrumental range, i.e., above the upper quantitation limit.

The relative percent difference and two sample t test criteria were applied to the means given in Appendix Tables A.4 through A.18. Computations included all nonsuspect measurements, including any marked as estimated (J) or as exceeding the quantitation range (E). Though some of the individual sample results for a given analyte marked as "valid" in Table 4.1 may not strictly meet the quantitation requirement, to discard such results would improperly skew the mean toward the quantitation range (e.g., BY-108 SUMMA™ canister dodecane means include individual results marked as "E").

The bases for excluding data from the reported means in Appendix Tables A.4 through A.18 were described in Section 3.0. Also, because there is clear evidence that the levels of hexane and 1-butanol in ISVS method samples from Tanks C-107 and S-102 were affected by the use of tape on the ISVS bundles, and because the use of this tape has subsequently been eliminated from the ISVS method, these data were not used in the evaluation of the ISVS method.

4.2 Statistical Methods

Two statistical criteria were used to compare the results from the VSS and the ISVS (without particle filter) methods. The effect of the particle filter can also be determined using similar statistical methods on the ISVS observations.

To evaluate the magnitude of the difference between the VSS and ISVS methods, the relative percent difference (RPD) of the means was computed. The RPD is the absolute value of the difference between the VSS mean and the ISVS mean divided by the VSS mean, times 100. In this comparison the VSS mean is the reference value. Specifically,

Table 4.1. Qualification of Results

Analyte	C-107			BY-108			S-102		
	Sorbent	SUMMA™	TST	Sorbent	SUMMA™	TST	Sorbent	SUMMA™	TST
Ammonia	valid			valid			valid		
Water Vapor	valid			valid			valid		
Hydrogen		valid			valid			valid	
Nitrous Oxide		valid			valid			valid	
Carbon Dioxide		valid			J			U	
Carbon Monoxide		U			U			U	
Methane		U			J			U	
TNMHC Vapors		valid			valid			valid	
Methanol		valid	valid		valid	E		E	E
Ethanol		valid	valid		valid	E		E	E
1-Propanol		valid	J		valid	valid		valid	valid
1-Butanol		S	S		valid	E		S	S
Acetonitrile		valid	valid		valid	valid		valid	valid
Propanenitrile		valid	valid		J	valid		J	J
Acetone		valid	valid		valid	E		valid	valid
2-Butanone		valid	valid		valid	valid		valid	valid
Tetrahydrofuran		U	U		valid	valid		valid	valid
Hexane		S	S		valid	E		S	S
Nonane		J	J		valid	valid		valid	valid
Decane		J	J		valid	valid		J	J
Undecane		valid	J		valid	valid		J	J
Dodecane		J	J		valid	E		U	J
Tridecane		J	J		valid	E		J	J
Tetradecane		U	J		valid	E		U	J
Tributyl phosphate			U			U			U
Total Analytes	2	12	6	2	18	8	2	9	6
U = Concentrations below instrument detection limit (IDL). J = Concentrations between IDL and estimated quantitation limit (EQL). E = Concentrations above upper calibration limit (UCL). S = Results considered suspect. valid = Results within instrument quantitation range.									

$$RPD = \frac{|\bar{X}_1 - \bar{X}_2|}{\bar{X}_1} 100 \quad (4.1)$$

where the means are the VSS and ISVS means defined in Equation 4.1. When the RPD is calculated for comparison of the mean analyte concentrations from ISVS with and without filters, the mean for ISVS without filter is the reference value ($\bar{X}_1$).

The second criterion was the use of a t test to compare the mean concentrations from the VSS and ISVS methods, or from the ISVS method with and without the particle filter. The statistical comparison was by tank and by analyte. The comparison, based on the t test, is described by Snedecor and Cochran (1980).

To compare VSS with ISVS a t-statistic was computed and compared with a tabulated quantile (two-tail test) from Student's t-distribution. The t-statistic is the absolute value of the difference between the means of the VSS and the ISVS observations divided by the estimated standard deviation of the difference between the means. Specifically, the t-statistic is

$$t = \frac{|\bar{X}_1 - \bar{X}_2|}{SD(\bar{X}_1 - \bar{X}_2)} \quad (4.2)$$

where $\bar{X}_1$, $\bar{X}_2$ and $SD(\bar{X}_1 - \bar{X}_2)$ are the means of VSS and ISVS, respectively, and SD is the standard deviation of the difference. The degrees of freedom is the total number of observations in the two means minus two and the level of significance is 0.05 (two-tailed test). The same statistical method is used to compare the means of ISVS sampling method with and without the particle filter. (See Snedecor and Cochran 1980, page 93, for explicit formulas).

If the computed t-statistic is greater than the tabulated value, $t(0.05, n_1 + n_2 - 2)$, where n_1 and n_2 are the number of VSS and ISVS observations respectively, then the means of VSS and ISVS are significantly different from each other (0.05 level of significance). If the computed t-statistic is less than the tabulated value, then the means of VSS and ISVS cannot be distinguished from each other.

For many analytes, the standard deviation of the data is very small, resulting in a small denominator in the t-statistic, and consequently, a large t-statistic value. When this occurs, even relatively small differences between the means may be indicated, by the t test, to be statistically significant at the 0.05 level of significance. The results of the t test should consequently be interpreted with caution since the difference in the means may be small enough that the two methods give results that can be used as "equivalent" by data users. The t test determines only which of the results are statistically different at the 0.05 level of significance and does not determine whether observed differences have consequences to the data users.

Tables 4.2, 4.3, and 4.4 summarize the results of the statistical comparison between the VSS and ISVS methods for Tanks C-107, BY-108, and S-102, respectively. The tables list each analyte, sampling device, mean analyte concentrations from the two sampling methods, the RPD and the t test results. If the RPD was greater than 30 percent, a ">30%" was entered in to the "Flag" column. If the calculated t-statistic was greater than the tabulated value (0.05 level of significance), the two means are significantly different from each other, and a "SD" was entered in the "Flag" column.

A summary of the statistical tests is given in Table 4.5. Table 4.5 lists the number of cases for which results differ by less than 30 percent, the number of cases for which the t test indicated the results to be not statistically distinguishable at the 0.05 level of significance, and the number of cases for which results are both statistically different and differ by more than 30 percent. As discussed in Section 1.4, for the purposes of vapor sampling, the VSS and ISVS methods will be considered equivalent unless both statistical criteria indicate the results to be different.

Tables 4.6 through 4.9 summarize the comparisons between concentration means from the ISVS method samples collected with and without particle filters. The format of these tables is identical to that of Tables 4.2 through 4.5, respectively.

Table 4.2. Tank C-107 Comparison of VSS and ISVS (without particle filter) Results

Analyte	Device	Units	VSS Mean	ISVS w/o filter Mean	t Test			Relative Percent Difference	
					Calculated t-statistic	Tabulated t(0.05)	Flag	Percent	Flag
Ammonia	Sorbent	ppmv	76	72	2.39	2.26	SD	5	
Water Vapor	Sorbent	mg/L	49	51	3.67	2.23	SD	3	
Hydrogen	SUMMA™	ppmv	242	241	0.38	2.23		0.5	
Nitrous Oxide	SUMMA™	ppmv	62.4	62.4	0.00	2.23		0.002	
Carbon Dioxide	SUMMA™	ppmv	693	701	4.54	2.23	SD	1	
TNMHC Vapors	SUMMA™	mg/m³	3.6	6.6	9.53	2.23	SD	82	> 30%
Methanol	SUMMA™	ppbv	1146	1231	0.98	2.23		7	
Methanol	TST	ppbv	1423	1240	0.87	2.23		13	
Ethanol	SUMMA™	ppbv	66	102	5.55	2.23	SD	55	> 30%
Ethanol	TST	ppbv	216	300	1.67	2.23		39	> 30%
1-Propanol	SUMMA™	ppbv	9.0	14	7.17	2.23	SD	50	> 30%
Acetonitrile	SUMMA™	ppbv	905	911	0.07	2.23		1	
Acetonitrile	TST	ppbv	623	488	3.47	2.23	SD	22	
Propanenitrile	SUMMA™	ppbv	121.2	120.6	0.12	2.23		0.5	
Propanenitrile	TST	ppbv	96	76	5.88	2.23	SD	21	
Acetone	SUMMA™	ppbv	617	621	0.08	2.23		1	
Acetone	TST	ppbv	295	202	5.47	2.23	SD	31	> 30%
2-Butanone	SUMMA™	ppbv	28	29	1.16	2.23		4	
2-Butanone	TST	ppbv	21	38	5.55	2.23	SD	81	> 30%
Undecane	SUMMA™	ppbv	5.1	4.6	1.18	2.23		10	
SD = statistically significantly different at the 0.05 significance level.									

Table 4.3. Tank BY-108 Comparison of VSS and ISVS (without particle filter) Results

Analyte	Device	Units	VSS Mean	ISVS w/o filter Mean	t Test			Relative Percent Difference	
					Calculated t-statistic	Tabulated t(0.05)	Flag	Percent	Flag
Ammonia	Sorbent	ppmv	801	770	2.79	2.23	SD	4	
Water Vapor	Sorbent	mg/L	14	14	3.24	2.23	SD	5	
Hydrogen	SUMMA™	ppmv	361	360	0.47	2.23		0.4	
Nitrous Oxide	SUMMA™	ppmv	470	461	2.22	2.23		1.8	
TNMHC Vapors	SUMMA™	mg/m³	222	203	6.81	2.23	SD	8	
Methanol	SUMMA™	ppbv	2067	2042	0.28	2.23		1	
Ethanol	SUMMA™	ppbv	1158	969	1.23	2.23		16	
1-Propanol	SUMMA™	ppbv	464	476	0.66	2.23		3	
1-Propanol	TST	ppbv	434	340	1.67	2.31		22	
1-Butanol	SUMMA™	ppbv	18900	18670	0.19	2.23		1	
Acetonitrile	SUMMA™	ppbv	131	147	0.70	2.23		12	
Acetonitrile	TST	ppbv	197	195	0.03	2.31		1	
Propanenitrile	TST	ppbv	14	13	0.34	2.31		10	
Acetone	SUMMA™	ppbv	2723	2434	0.46	2.23		11	
2-Butanone	SUMMA™	ppbv	286	291	0.06	2.23		2	
2-Butanone	TST	ppbv	296	247	1.46	2.31		17	
Tetrahydrofuran	SUMMA™	ppbv	748	749	0.04	2.23		0.2	
Tetrahydrofuran	TST	ppbv	742	594	1.78	2.31		20	
Hexane	SUMMA™	ppbv	1071	1066	0.17	2.23		0.5	
Nonane	SUMMA™	ppbv	76	75	0.41	2.23		1	
Nonane	TST	ppbv	82	71	1.00	2.31		13	
Decane	SUMMA™	ppbv	115	111	0.97	2.23		3	
Decane	TST	ppbv	101	86	1.03	2.31		15	
Undecane	SUMMA™	ppbv	218	199	1.48	2.23		9	
Undecane	TST	ppbv	254	219	0.95	2.31		14	
Dodecane	SUMMA™	ppbv	732	638	1.99	2.23		13	
Tridecane	SUMMA™	ppbv	545	355	3.96	2.23	SD	35	> 30%
Tetradecane	SUMMA™	ppbv	459	176	4.12	2.23	SD	69	> 30%

SD = statistically significantly different at the 0.05 significance level.

Table 4.4. Tank S-102 Comparison of VSS and ISVS (without particle filter) Results

Analyte	Device	Units	VSS Mean	ISVS w/o filter Mean	t Test			Relative Percent Difference	
					Calculated t-statistic	Tabulated t(0.05)	Flag	Percent	Flag
Ammonia	Sorbent	ppmv	622	595	2.02	2.23		4	
Water Vapor	Sorbent	mg/L	14	13	3.87	2.23	SD	8	
Hydrogen	SUMMA™	ppmv	737	725	5.52	2.18	SD	2	
Nitrous Oxide	SUMMA™	ppmv	697	690	1.79	2.18		1	
TNMHC Vapors	SUMMA™	mg/m³	16	18	2.50	2.18	SD	9	
1-Propanol	SUMMA™	ppbv	37	39	0.65	2.18		4	
1-Propanol	TST	ppbv	55	58	0.79	2.26		7	
Acetonitrile	SUMMA™	ppbv	43	27	4.50	2.18	SD	37	> 30%
Acetonitrile	TST	ppbv	65	89	3.94	2.26	SD	38	> 30%
Acetone	SUMMA™	ppbv	433	447	0.21	2.18		3	
Acetone	TST	ppbv	255	315	4.91	2.26	SD	24	
2-Butanone	SUMMA™	ppbv	51	58	1.50	2.18		14	
2-Butanone	TST	ppbv	59	61	0.71	2.26		3	
Tetrahydrofuran	SUMMA™	ppbv	47	46	0.38	2.18		1	
Tetrahydrofuran	TST	ppbv	53	52	0.45	2.26		1	
Nonane	SUMMA™	ppbv	1.94	1.89	0.51	2.18		3	
Nonane	TST	ppbv	3.2	3.7	5.52	2.26	SD	16	
SD = statistically significantly different at the 0.05 significance level.									

Table 4.5. Summary of Statistical Comparisons between VSS and ISVS (without particle filter)

Analytes	Results with Relative Percent Difference < 30 %	Results with t Test Significance Level > 0.05	Results Not Meeting Either Criteria
Permanent Gases (7 results for H ₂ , N ₂ O, CO ₂)	7	5	0
Inorganic Vapors (6 results for NH ₃ , H ₂ O)	6	1	0
Total Nonmethane Hydrocarbon Vapors (3 results)	2	0	1
Organic Vapors (49 results for 18 compounds)	40	37	8
Total (65 results)	55	43	9

Table 4.6. Tank C-107 Comparison of ISVS Method with and without Particle Filter

Analyte	Device	Units	ISVS w/o filter Mean	ISVS w/ filter Mean	t Test			Relative Percent Difference	
					Calculated t-statistic	Tabulated t(0.05)	Flag	Percent	Flag
Ammonia	Sorbent	ppmv	72	73	0.36	2.23		1	
Water Vapor	Sorbent	mg/L	51	49	4.17	2.23	SD	4	
Hydrogen	SUMMA™	ppmv	241	233	2.77	2.23	SD	3	
Nitrous Oxide	SUMMA™	ppmv	62	60	5.61	2.23	SD	4	
Carbon Dioxide	SUMMA™	ppmv	701	693	7.16	2.23	SD	1	
TNMHC Vapors	SUMMA™	mg/m ³	6.6	4.2	6.74	2.23	SD	37	> 30%
Methanol	SUMMA™	ppbv	1231	1179	0.64	2.23		4	
Methanol	TST	ppbv	1240	1663	3.45	2.23	SD	34	> 30%
Ethanol	SUMMA™	ppbv	102	81	3.23	2.23	SD	20	
Ethanol	TST	ppbv	300	290	0.18	2.23		3	
1-Propanol	SUMMA™	ppbv	14	12	1.73	2.23		11	
Acetone	SUMMA™	ppbv	621	579	0.91	2.23		7	
Acetone	TST	ppbv	204	222	1.57	2.23		9	
2-Butanone	SUMMA™	ppbv	29	26	2.87	2.23	SD	10	
2-Butanone	TST	ppbv	38	24	4.41	2.23	SD	37	> 30%
Acetonitrile	SUMMA™	ppbv	911	849	0.91	2.23		7	
Acetonitrile	TST	ppbv	492	597	3.88	2.23	SD	21	
Propanenitrile	SUMMA™	ppbv	121	113	0.59	2.23		7	
Propanenitrile	TST	ppbv	76	85	0.41	2.23		12	
Undecane	SUMMA™	ppbv	4.6	4.4	0.64	2.23		4	
SD = statistically significantly different at the 0.05 significance level.									

Table 4.7. Tank BY-108 Comparison of ISVS Method with and without Particle Filter

Analyte	Device	Units	ISVS w/o filter Mean	ISVS w/ filter Mean	t Test			Relative Percent Difference	
					Calculated t-statistic	Tabulated t(0.05)	Flag	Percent	Flag
Ammonia	Sorbent	ppmv	770	787	1.40	2.23		2	
Water Vapor	Sorbent	mg/L	14	14	1.38	2.31		3	
Hydrogen	SUMMA™	ppmv	360	347	3.51	2.23	SD	4	
Nitrous Oxide	SUMMA™	ppmv	461	447	4.14	2.23	SD	3	
TNMHC Vapors	SUMMA™	mg/m3	203	187	4.22	2.23	SD	8	
Methanol	SUMMA™	ppbv	2042	2004	0.43	2.23		2	
Ethanol	SUMMA™	ppbv	969	952	0.33	2.23		2	
1-Propanol	SUMMA™	ppbv	476	447	1.37	2.23		6	
1-Propanol	TST	ppbv	340	414	1.09	2.37		22	
1-Butanol	SUMMA™	ppbv	18670	17730	1.01	2.23		5	
Acetonitrile	SUMMA™	ppbv	147	126	1.05	2.23		14	
Acetonitrile	TST	ppbv	195	264	1.85	2.37		35	> 30%
Propanenitrile	TST	ppbv	13	17	1.35	2.37		36	> 30%
Acetone	SUMMA™	ppbv	2434	1988	1.00	2.23		18	
2-Butanone	SUMMA™	ppbv	291	262	0.40	2.23		10	
2-Butanone	TST	ppbv	247	349	2.38	2.37	SD	41	
Tetrahydrofuran	SUMMA™	ppbv	749	701	1.12	2.23		6	
Tetrahydrofuran	TST	ppbv	594	729	1.82	2.37		23	
Hexane	SUMMA™	ppbv	1066	1039	0.77	2.23		3	
Nonane	SUMMA™	ppbv	75	68	2.71	2.23	SD	9	
Nonane	TST	ppbv	71	72	0.06	2.37		1	
Decane	SUMMA™	ppbv	111	100	2.86	2.23	SD	10	
Decane	TST	ppbv	86	79	0.51	2.37		8	
Undecane	SUMMA™	ppbv	199	181	2.13	2.23		9	
Undecane	TST	ppbv	219	182	0.97	2.37		17	
Dodecane	SUMMA™	ppbv	638	513	2.77	2.23	SD	20	
Tridecane	SUMMA™	ppbv	355	272	2.00	2.23		23	
Tetradecane	SUMMA™	ppbv	176	93	1.79	2.23		47	> 30%

SD = statistically significantly different at the 0.05 significance level.

Table 4.8. Tank S-102 Comparison of ISVS Method with and without Particle Filter

Analyte	Device	Units	ISVS w/o filter Mean	ISVS w/ filter Mean	t Test			Relative Percent Difference	
					Calculated t-statistic	Tabulated t(0.05)	Flag	Percent	Flag
Ammonia	Sorbent	ppmv	595	615	1.46	2.23		3	
Water Vapor	Sorbent	mg/L	13	13	0.32	2.23		1	
Hydrogen	SUMMA™	ppmv	725	689	6.27	2.23	SD	5	
Nitrous Oxide	SUMMA™	ppmv	690	650	6.38	2.23	SD	6	
TNMHC Vapors	SUMMA™	mg/m3	18	16	2.21	2.23		10	
1-Propanol	SUMMA™	ppbv	39	39	0.24	2.23		2	
1-Propanol	TST	ppbv	58	48	1.94	2.26		17	
Acetonitrile	SUMMA™	ppbv	27	34	1.48	2.23		27	
Acetonitrile	TST	ppbv	89	60	5.86	2.26	SD	33	> 30%
Acetone	SUMMA™	ppbv	447	469	0.25	2.23		5	
Acetone	TST	ppbv	315	237	5.96	2.26	SD	25	
2-Butanone	SUMMA™	ppbv	58	46	2.15	2.23		21	
2-Butanone	TST	ppbv	61	50	3.10	2.26	SD	18	
Tetrahydrofuran	SUMMA™	ppbv	46	43	4.06	2.23	SD	8	
Tetrahydrofuran	TST	ppbv	52	45	3.12	2.26	SD	14	
Nonane	SUMMA™	ppbv	1.9	1.7	2.71	2.23	SD	11	
Nonane	TST	ppbv	3.7	3.0	7.23	2.26	SD	19	
SD = statistically significantly different at the 0.05 significance level.									

Table 4.9. Summary of Statistical Comparisons between ISVS with and without Particle Filter

Analytes	Results with t Test Significance Level > 0.05	Results with Relative Percent Difference < 30 %	Results Not Meeting Either Criteria
Permanent Gases (7 results for H ₂ , N ₂ O, CO ₂)	0	7	0
Inorganic Vapors (6 results for NH ₃ , H ₂ O)	5	6	0
Total Nonmethane Hydrocarbon Vapors (3 results)	1	2	1
Organic Vapors (49 results for 18 compounds)	33	43	3
Total (65 results)	39	58	4

5.0 Discussion

5.1 Comparison of ISVS and VSS Methods

5.1.1 Ammonia and Water Vapor

The agreement between the VSS and ISVS method means for ammonia and water vapor is excellent. As shown in Tables 4.2 through 4.4, RPD values for the analyte means range from 3 to 8 percent, and well below the 30 percent upper criterion. This agreement clearly demonstrates that sample volume measurement with the ISVS equipment is as good as that of the VSS for the 2-L samples and current uses of the data. Total measurement precision, which includes random errors from both the sampling and analytical processes, is also excellent. Precision, measured as the percent relative standard deviation (% RSD), ranges from less than 1 percent to about 5 percent for these two analytes (see Appendix Tables A.4 through A.6).

As indicated in Tables 4.2 through 4.4, ammonia and water vapor means for all three tanks sampled were statistically significantly different (0.05 level of significance). This should not be surprising because the precision for these measurements is very good, and even small differences in the means indicate statistically significant differences. Small differences in sample volume measurement or improper corrections for passive sampling may have caused the difference in the means.

In summary, the relative differences between the VSS and ISVS method measurements of ammonia and water vapor were much smaller than the allowed 30 percent, and the methods should be considered equivalent for these compounds.

5.1.2 Permanent Gases

Hydrogen and nitrous oxide were present in Tanks C-107, BY-108, and S-102 at easily detected concentrations. Carbon monoxide and methane were below quantitation levels in all three tanks. Methane in Tank BY-108 was above the instrument detection limit and, though all values are estimated, agreement between the ISVS and VSS methods as indicated in Appendix Table A.8 is good.

Carbon dioxide was significantly above ambient air concentrations in Tank C-107 (ambient air contains 350 to 400 ppmv of carbon dioxide). It was also detected at low levels by both sampling methods in Tank BY-108, and via the ISVS method in Tank S-102. The increased levels of carbon dioxide in ISVS method samples in both Tanks BY-108 and S-102 may be indicative of faulty tubing connections within the ISVS bundle head, which allowed small amounts of ambient air within the bundle to enter the sample line. This premise is supported by slightly lower values for both hydrogen and nitrous oxide in the ISVS method SUMMA™ canisters for both these tanks. Subsequent to these sampling events, the connection of the SUMMA™ line in the ISVS bundle was improved.

RPD values for the permanent gases given in Appendix Tables 4.2 through 4.4 range from about 0.3 to about 2 percent, and are all far below the 30 percent criteria. The results of the t test, also given in Tables 4.2 through 4.4, indicate two of the seven permanent gas measurement comparisons of means are significantly different (0.05 level of significance). As with the ammonia and water vapor measurements, this stems more from the high precision of the measurements than from the magnitude of their differences. For example, mean carbon dioxide concentrations for Tank C-107 via VSS and ISVS methods differed by only about 1 percent (i.e., 693 and 701 ppmv, respectively), yet were indicated to be statistically significantly different because their relative standard deviations were only 0.6 and 0.2 percent, respectively.

The excellent agreement of the VSS and ISVS permanent gas results validates the use of unheated transfer tubing to sample the permanent gases. Although water vapor condensate was observed in the SUMMA™ sampling tubing during the Tank C-107 event (Tank C-107 has a dew point over 40°C, and the tubing itself was near the ambient 0°C), it did not significantly reduce the transport of carbon dioxide.

In summary, relative differences between the VSS and ISVS method measurements of the permanent gases were found to be much smaller than the allowed 30 percent for all cases. The methods should be considered equivalent for these compounds.

5.1.3 Total Nonmethane Hydrocarbon Vapors

The differences between the TNMHC means from the VSS and ISVS methods in both Tanks BY-108 and S-102, as measured by RPDs, are well below the 30 percent criteria. The Tank C-107 mean TNMHC result from the ISVS method is 82 percent higher than the mean from the VSS, apparently because these samples were contaminated by volatiles from an adhesive tape (see Section 3.3). A review by the responsible analytical chemist of the positively and tentatively identified compounds detected in the Tank C-107 ISVS method SUMMA™ canister samples (the same samples used to measure TNMHC) indicated that the higher TNMHC concentration in these samples was due to compounds associated with the tape.

The t-statistics for ISVS and VSS TNMHC vapor measurements given in Tables 4.2 through 4.4 indicate that their means were statistically significantly different (at the 0.05 significance level) in each of the three studied tanks. In both Tanks C-107 and S-102, the apparent cause for these differences is the contamination from the adhesive tape applied to the ISVS bundle. Though quantitation of all the tape contaminants has not been performed, they appear to be present at sufficient levels to account for the elevated TNMHC measurements in Tanks C-107 and S-102. TNMHC results by the VSS and ISVS methods for Tank BY-108 are consistent with the expectation that vapors of semivolatile organic wastes in that tank are probably not faithfully transported via unheated tubing to the SUMMA™ canisters. The error associated with this limitation (RPD in Table 4.3 is about 8 percent) is nevertheless smaller than allowed by the SAP.

In summary, relative differences between the VSS and ISVS method measurements of TNMHC vapors were found to be less than the 30 percent criterion in Tanks S-102 and BY-108 but greater than this criterion in Tank C-107. The differences in Tank C-107 results are apparently due to contamination from tape used on the ISVS bundle, which will not be used in the future. The TNMHC measurements were statistically significant (at the 0.05 significance level) in each of the three tanks; however, the differences can be understood in terms of the contamination problem and an expected sampling bias associated with high levels of semivolatile organic vapors.

5.1.4 Organic Vapors in SUMMA™ Canister Samples

The t-statistics and RPDs for organic vapors measured in SUMMA™ canisters are given in Tables 4.2, 4.3, and 4.4 for Tanks C-107, BY-108, and S-102, respectively. Of the 29 comparisons of means, five are indicated to differ by more than the 30 percent limit. Each of these are also indicated to be statistically significantly different (0.05 level of significance). In two of the five cases, the mean concentration measured by the ISVS method is higher than the mean from the VSS samples. Of the other three cases, both tridecane and tetradecane concentration means in Tank BY-108 samples are understandably lower in the ISVS samples because these samples were collected via an unheated tube on a very cold day.

In summary, differences between the VSS and ISVS method measurement means of organic vapors in SUMMA™ canisters were within the 30 percent criterion in 24 of 29 cases. In the remaining five cases, the means differed by more than 30 percent and were statistically significantly different at the 0.05 significance level. Two of the five cases appear to confirm the expectation that higher concentrations of low volatility compounds are not transferred quantitatively in unheated transfer tubing. Aside from the poor transfer of these two semivolatile hydrocarbons in the ISVS transfer tubing in Tank BY-108 samples, the VSS results are not indicated to be more valid than the ISVS results (i.e., there is no consistent sampling bias).

5.1.5 Organic Vapors in Triple Sorbent Traps

TST organic vapor means for the ISVS and VSS methods are given and compared in Tables 4.2 through 4.4. Relative differences between the means from the two sampling methods are within the 30 percent criterion in 16 of 20 cases. Seven of the 20 comparisons indicated the means to be significantly different at the 0.05 significance level, and three of these statistically different results also differed by more than 30 percent. The largest RPD for any of the TST comparisons of means was 81 percent. Of the three sets of results that both differed by more than 30 percent and were statistically significantly different, there was no apparent bias for either sampling method giving higher or lower mean concentrations.

As with the SUMMA™ canister organic vapor measurements, differences between the VSS and ISVS methods may not be important compared to the overall ability to measure the concentrations. Organic vapor measurements from TSTs and SUMMA™ canisters generally differ by much more than

the differences noted between the VSS and ISVS methods (e.g., compare Appendix Tables A.13 and A.16, Tables A.14 and A.17, Tables A.15 and A.18).

In summary, differences between the VSS and ISVS method measurements of organic vapors in TSTs were found to satisfy the comparison criteria in 17 of 20 cases. No simple sampling bias is apparent for the studied organic vapors, and the differences between TST and SUMMA™ canister methods are generally greater than the differences between the VSS and ISVS methods.

5.2 Comparison of ISVS With and Without Particle Filters

The same statistical tools were used to examine differences between ISVS method samples collected with and without a particle filter. Tables 4.6 through 4.9 summarize the analyte means and statistical tests applied. Considering the comparisons in aggregate, seven of the 65 pairs of means were determined to differ by more than 30 percent, and 26 pairs of means were determined to be significantly different at the 0.05 significance level. In 24 of the 27 cases, when the samples were filtered the mean concentration was lower than when the samples were not filtered. This was apparently due in part to leaks in the filtered ISVS method SUMMA™ canister transfer tubing, but also suggests that some loss of constituents by adsorption does occur on the filter. However, only four of the 65 pairs of means were both significantly different (0.05 level of significance) and had RPDs of more than 30 percent.

Unfortunately, the most important analyte for the particle filter tests, tributyl phosphate, was not detected in any of the samples. TSTs have been demonstrated in the laboratory to serve as adequate sampling devices for tributyl phosphate (SUMMA™ canisters are not good devices for tributyl phosphate vapor). The TST analytical method has also been demonstrated to be quite sensitive to tributyl phosphate (instrument detection limits correspond to less than 1 ppbv for the TSTs of this study [Pool et al. 1996]). Consequently, because the ISVS method without particle filtration was exposed directly to tank air, it can be concluded that the levels of tributyl phosphate in Tanks C-107, BY-108, and S-102 were below instrument detection levels.

5.3 Comparison of Results with Action Levels

Tank headspace characterization data are used to estimate regulated air emissions and to screen for flammable and toxicologically significant constituents. The specified accuracy with which concentrations are to be measured is currently ± 30 percent of the reported value (regardless of proximity to the action level). This section compares data from this comparison study with the current action levels.

As discussed in the previous sections, nine of the 65 pairs of VSS and ISVS results are statistically significantly different at the 5 percent significance level and also have a relative percent difference of greater than 30 percent. These nine results are associated with six compounds and one measurement of TNMHC vapors (one compound, acetonitrile, appears twice). To illustrate these data and their differences relative to action levels, they have been plotted in Figures 5.1 through 5.9 along with relevant action levels. In the plot at the top of each figure, individual sample results for the VSS and

Figure 5.1. Total Nonmethane Hydrocarbon Concentrations (mg/m³) in Tank C-107

Figure 5.2. Ethanol Concentrations (ppm) in Tank C-107 SUMMA™ Canister Samples

Figure 5.3. 1-Propanol Concentrations (ppm) in Tank C-107 SUMMA™ Canister Samples

Figure 5.4. Acetone Concentrations (ppm) in Tank C-107 Triple Sorbent Trap Samples

Figure 5.5. 2-Butanone Concentrations (ppm) in Tank C-107 Triple Sorbent Trap Samples

Figure 5.6. Tridecane Concentrations (ppm) in Tank BY-108 SUMMA™ Samples

Figure 5.7. Tetradecane Concentrations (ppm) in Tank BY-108 SUMMA™ Samples

Figure 5.8. Acetonitrile Concentrations (ppm) in Tank S-102 SUMMA™ Samples

Figure 5.9. Acetonitrile Concentrations (ppm) in Tank S-102 Triple Sorbent Trap Samples

ISVS (without particle filter) methods are plotted on a scale that maximizes differences. The same individual sample results are replotted in the bottom of each figure; however, the abscissa was rescaled to allow inclusion of the lowest applicable action limit. Visual inspection of these plots in the lower halves of the figures suggests that the sampling methods give essentially equivalent results. The action levels presented in Figures 5.1 through 5.9 are described below.

The SAP specifies two action levels that are based on the lower flammability limit (LFL) and the level considered by the National Institute for Occupational Safety and Health (NIOSH 1995) to be immediately dangerous to life or health (IDLH). If analytical results exceed 20 percent of the LFL or 50 percent of the IDLH value, the SAP requires the analytical laboratory to notify key Westinghouse Hanford Company (WHC) personnel (Homi 1996). Appendix Tables A.19 through A.24 list the LFL and IDLH values for each analyte in this study, along with the percent of LFL and percent IDLH for each of the results. Of all analytes considered, only ammonia exceeded the notification criteria, being well above 50 percent of its IDLH in both Tanks BY-108 and S-102.

In addition to the LFL and IDLH action levels, air emissions action levels apply if tank headspace characterization results are used to obtain an air permit for a portable exhauster. Under the current agreement with the Washington State Department of Ecology, WHC must characterize the toxic air pollutant (TAP) levels in each tank headspace before use of the rotary mode core system (RMCS) portable exhauster on the tank (DOE 1995). The agreement specifies formulas for determining whether any given TAP present in the tank headspace would exceed allowed small quantity emission levels. Though none of the analytes in this study have very low air emission action levels, constituents identified in other tanks do have air emission action levels much lower than the LFL or IDLH limits. For example, 1,3-butadiene has an air emission action level of 0.055 ppmv.

5.4 Summary

The VSS and ISVS methods gave almost identical results for the five permanent gases; the largest relative difference between the methods for quantitated hydrogen, nitrous oxide, and carbon dioxide results was two percent, and both methods indicated carbon monoxide to be below instrument detection limits in all cases. Similarly, the methods were in excellent agreement on the ammonia and water vapor results; the largest percent difference for the six compared cases was 8 percent. The total nonmethane hydrocarbon and individual organic vapor measurements indicated differences between the methods in some cases, but the lack of apparent bias suggested the ISVS method is not inherently inferior to the VSS method.

The two statistical criteria indicated the VSS and ISVS methods to be equivalent in 56 of the 65 cases examined. Of the nine cases for which the methods were indicated to be nonequivalent, one can be attributed to the off-gassing of adhesive tape used on the ISVS bundle, and six of the others show no consistent bias that would indicate either sampling method to be inadequate. Two sets of results do indicate there is sampling bias for high levels of semivolatile organic vapors when SUMMA™ canister samples are collected by the ISVS method, as was anticipated. This limitation of ISVS SUMMA™ canister samples does not negate the use of the ISVS method as a screening method for

semivolatile organic vapors because these vapors are also characterized by TST samples. However, it does suggest that the VSS method provides better SUMMA™ canister samples for characterizing high levels of semivolatile organic vapors.

Problems associated with the initial use of the ISVS method (e.g., adhesive tape off-gassing and imperfect SUMMA™ transfer line connections) resulted in the loss of some data and had small adverse effects on the comparison of the two methods. However, the missing data involve compounds similar to ones that were included in the comparison test, and no major gas or vapor type was unrepresented.

Tests of the ISVS system with and without a particulate filter were conducted to assess the removal of tributyl phosphate and other semivolatile organic vapors by the filters. Results indicated that the filters did adversely affect the collection of low volatility organic vapors; however, because tributyl phosphate was not detected in any of the samples (filtered or unfiltered), the effect of the filters on tributyl phosphate could not be determined. Because the filters do affect the sampling, future production sampling should be conducted without the filters.

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Appendix

Table A.1. Tank C-107 Headspace Samples

	VSS	ISVS with particle filter		ISVS without particle filter
			Bundle	Bundle C
Ammonia and Water Vapor Sorbent Traps	S6001-A18.21S	S6002-A42.30S	A	S6003-A66.38S
	S6001-A19.22S	S6002-A43.31S	A	S6003-A67.39S
	S6001-A20.23S	S6002-A44.32S	A	S6003-A68.40S
	S6001-A21.24S	S6002-A51.33S	B	S6003-A69.41S
	S6001-A22.25S	S6002-A52.34S	B	S6003-A70.42S
	S6001-A23.26S	S6002-A53.35S	B	S6003-A71.43S
SUMMA™ Canisters	S6001-A03.302	S6002-A36.310	A	S6003-A54.317
	S6001-A04.303	S6002-A37.311	A	S6003-A55.318
	S6001-A15.304	S6002-A38.312	A	S6003-A56.319
	S6001-A16.305	S6002-A45.313	B	S6003-A57.320
	S6001-A27.306	S6002-A46.314	B	S6003-A58.321
	S6001-A28.307	S6002-A47.315	B	S6003-A59.322
Triple Sorbent Traps	S6001-A05.773	S6002-A39.784	A	S6003-A60.791
	S6001-A06.774	S6002-A40.785	A	S6003-A62.794
	S6001-A07.775	S6002-A41.786	A	S6003-A63.796
	S6001-A08.776	S6002-A48.788	B	S6003-A64.797
	S6001-A09.777	S6002-A49.789	B	S6003-A65.798
	S6001-A10.778	S6002-A50.790	B	S6003-A66.792

Table A.2. Tank BY-108 Headspace Samples

	VSS	ISVS with particle filter		ISVS without particle filter
			Bundle	Bundle C
Ammonia and Water Vapor Sorbent Traps	S6004-A18.46S	S6005-A42.55S	A	S6006-A66.63S
	S6004-A19.47S	S6005-A43.56S	A	S6006-A67.64S
	S6004-A20.48S	S6005-A44.57S	A	S6006-A68.65S
	S6004-A21.49S	S6005-A51.58S	B	S6006-A69.66S
	S6004-A22.50S	S6005-A52.59S	B	S6006-A70.67S
	S6004-A23.51S	S6005-A53.60S	B	S6006-A71.68S
SUMMA™ Canisters	S6004-A03.029	S6005-A36.114	A	S6006-A54.182
	S6004-A04.050	S6005-A37.116	A	S6006-A55.208
	S6004-A15.054	S6005-A38.138	A	S6006-A56.211
	S6004-A16.055	S6005-A45.143	B	S6006-A57.228
	S6004-A27.067	S6005-A46.145	B	S6006-A58.323
	S6004-A28.080	S6005-A47.154	B	S6006-A59.324
Triple Sorbent Traps	S6004-A05.707	S6005-A39.731	A	S6006-A60.744 ^(a)
	S6004-A06.708	S6005-A40.732	A	S6006-A61.745
	S6004-A07.709	S6005-A41.733	A	S6006-A62.754
	S6004-A08.710	S6005-A48.734	B	S6006-A63.755
	S6004-A09.711	S6005-A49.738	B	S6006-A64.756 ^(a)
	S6004-A10.715	S6005-A50.741	B	S6006-A65.758

(a) Sample not analyzed due to breakage.

Table A.3. Tank S-102 Headspace Samples

	VSS	ISVS with particle filter		ISVS without particle filter
			Bundle	Bundle C
Ammonia and Water Vapor Sorbent Traps	S6007-A18.71S	S6008-A42.80S	A	S6009-A66.88S
	S6007-A19.72S	S6008-A43.81S	A	S6009-A67.89S
	S6007-A20.73S	S6008-A44.82S	A	S6009-A68.90S
	S6007-A21.74S	S6008-A51.83S	B	S6009-A69.91S
	S6007-A22.75S	S6008-A52.84S	B	S6009-A70.92S
	S6007-A23.76S	S6008-A53.85S	B	S6009-A71.93S
SUMMA™ Canisters	S6007-A03.082	S6008-A36.128	A	S6009-A54.167
	S6007-A04.083	S6008-A37.129	A	S6009-A55.169
	S6007-A15.084	S6008-A38.134	A	S6009-A56.170
	S6007-A16.097	S6008-A45.136	B	S6009-A57.229
	S6007-A27.108	S6008-A46.137	B	S6009-A58.230
	S6007-A28.120	S6008-A47.153	B	S6009-A59.248
	S6007-A87.086			
	S6007-A88.089			
Triple Sorbent Traps	S6007-A05.806	S6008-A39.817	A	S6009-A61.828
	S6007-A06.807	S6008-A40.818	A	S6009-A62.830
	S6007-A07.808	S6008-A41.819	A	S6009-A63.831
	S6007-A08.809	S6008-A48.821	B	S6009-A64.832

Table A.4. Tank C-107 Ammonia and Water Vapor

	Water Vapor (mg/L)	Ammonia (ppmv)
VSS		
S6001-A18.21S	48.8	75.4
S6001-A19.22S	48.6	74.1
S6001-A20.23S	49.1	75.4
S6001-A21.24S	49.1	64 ^(a)
S6001-A22.25S	49.5	78.7
S6001-A23.26S	49.3	76.3
Mean	49.1	76.0
% RSD	1	2
ISVS with filter		
S6002-A42.30S	47.9	71.3
S6002-A43.31S	49.2	75.0
S6002-A44.32S	48.1	71.2
S6002-A51.33S	48.2	76.8
S6002-A52.34S	49.7	69.8
S6002-A53.35S	48.0	73.6
Mean	48.5	73.0
% RSD	2	4
ISVS without filter		
S6003-A66.38S	50.0	69.1
S6003-A67.39S	48.9	75.4
S6003-A68.40S	50.9	71.2
S6003-A69.41S	51.2	76.4
S6003-A70.42S	51.4	69.7
S6003-A71.43S	51.1	72.4
Mean	50.6	72.4
% RSD	2	4
Grand Mean	49.4	73.6
% RSD	2	4

(a) Result suspect and not included in statistics.

Table A.5. Tank BY-108 Ammonia and Water Vapor

	Water Vapor (mg/L)	Ammonia (ppmv)
VSS		
S6004-A18.46S	14.3	800
S6004-A19.47S	14.3	789
S6004-A20.48S	14.6	809
S6004-A21.49S	14.4	815
S6004-A22.50S	14.5	809
S6004-A23.51S	14.4	783
Mean	14.4	801
% RSD	0.8	2
ISVS with filter		
S6005-A42.55S	14.3	799
S6005-A43.56S	22.2 ^(a)	759
S6005-A44.57S	63.6 ^(a)	803
S6005-A51.58S	13.7	795
S6005-A52.59S	14.2	797
S6005-A53.60S	14.2	770
Mean	14.1	787
% RSD	2	2.3
ISVS without filter		
S6006-A66.63S	13.6	749
S6006-A67.64S	13.9	787
S6006-A68.65S	13.5	768
S6006-A69.66S	13.6	743
S6006-A70.67S	13.0	808
S6006-A71.68S	14.6	764
Mean	13.7	770
% RSD	4	3
Grand Mean	14.1	786
% RSD		

(a) Result suspect and not included in statistics.

Table A.6. Tank S-102 Ammonia and Water Vapor

	Water Vapor (mg/L)	Ammonia (ppmv)
VSS		
S6007-A18.71S	14.3	621
S6007-A19.72S	14.0	598
S6007-A20.73S	13.9	642
S6007-A21.74S	13.8	622
S6007-A22.75S	13.9	631
S6007-A23.76S	14.1	617
Mean	14.0	622
% RSD	1	2
ISVS with filter		
S6008-A42.80S	12.4	588
S6008-A43.81S	12.9	616
S6008-A44.82S	12.6	614
S6008-A51.83S	13.7	621
S6008-A52.84S	12.6	622
S6008-A53.85S	13.6	627
Mean	13.0	615
% RSD	4	2
ISVS without filter		
S6009-A66.88S	12.0	584
S6009-A67.89S	12.9	618
S6009-A68.90S	12.9	581
S6009-A69.91S	12.1	550
S6009-A70.92S	13.4	613
S6009-A71.93S	13.8	626
Mean	12.9	595
% RSD	5	5
Grand Mean	13.3	611
% RSD	5	4

Table A.7. Tank C-107 Permanent Gases

	Hydrogen (ppmv)		Nitrous Oxide (ppmv)		Carbon Dioxide (ppmv)		Carbon Monoxide (ppmv)		Methane (ppmv)	
VSS										
S6001-A03.302	237		64		695			U		U
S6001-A04.303	249		61		687			U		U
S6001-A15.304	238		61		699			U		U
S6001-A16.305	237		61		689			U		U
S6001-A27.306	248		64		694			U		U
S6001-A28.307	243		63		692			U		U
Mean	242		62		693			U		U
% RSD	2		2		1					
ISVS with filter										
S6002-A36.310	221		59		693			U		U
S6002-A37.311	231		60		691			U		U
S6002-A38.312	234		60		693			U		U
S6002-A45.313	237		61		697			U		U
S6002-A46.314	233		59		695			U		U
S6002-A47.315	240		58		690			U		U
Mean	233		60		693			U		U
% RSD	3		2		0.4					
ISVS without filter										
S6003-A54.317	237		61		700			U		U
S6003-A55.318	246		62		701			U		U
S6003-A56.319	243		63		703			U		U
S6003-A57.320	237		63		701			U		U
S6003-A58.321	242		62		703			U		U
S6003-A59.322	240		62		699			U		U
Mean	241		62		701			U		U
% RSD	1		1		0.2					
Grand Mean	238		61		696			U		U
% RSD	3		3		1					

U = Result below instrument detection limit (IDL).

Table A.8. Tank BY-108 Permanent Gases

	Hydrogen (ppmv)		Nitrous Oxide (ppmv)		Carbon Dioxide (ppmv)		Carbon Monoxide (ppmv)		Methane (ppmv)	
VSS										
S6004-A03.029	364		465		14	J		U	13	J
S6004-A04.050	362		481		10	J		U	14	J
S6004-A15.054	362		472		12	J		U	16	J
S6004-A16.055	354		472		9	J		U	14	J
S6004-A27.067	352		461		11	J		U	19	J
S6004-A28.080	372		466		13	J		U	15	J
Mean	361		469		12	J		U	15.4	J
% RSD	2		1		16				15	
ISVS with filter										
S6005-A36.114	345		453		32			U	15	J
S6005-A37.116	348		445		29			U	17	J
S6005-A38.138	338		444		27			U	12	J
S6005-A45.143	339		440		29			U	18	J
S6005-A46.145	358		453		30			U	16	J
S6005-A47.154	351		445		32			U	15	J
Mean	346		447		30			U	15.4	J
% RSD	2		1		6.0				12	
ISVS without filter										
S6006-A54.182	364		456		19	J		U	14	J
S6006-A55.208	358		470		17	J		U	20	J
S6006-A56.211	357		455		16	J		U	16	J
S6006-A57.228	356		466		17	J		U	17	J
S6006-A58.323	367		464		19	J		U	12	J
S6006-A59.324	355		455		14	J		U	18	J
Mean	359		461		17	J		U	16.1	J
% RSD	1		1		11				18	
Grand Mean	355		459		19	J		U	15.6	J
% RSD	3		2		41				14	

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.9. Tank S-102 Permanent Gases

	Hydrogen (ppmv)		Nitrous Oxide (ppmv)		Carbon Dioxide (ppmv)		Carbon Monoxide (ppmv)	Methane (ppmv)	
VSS									
S6007-A03.082	736		707			U		U	
S6007-A04.083	740		692			U		U	
S6007-A15.084	738		699			U		U	
S6007-A16.097	738		700			U		U	J
S6007-A27.108	736		695			U		U	
S6007-A28.120	736		702			U		U	
S6007-A87.086	740		689			U		U	
S6007-A88.089	734		689			U		U	
Mean	737		696			U		U	
% RSD	0.3		1						
ISVS with filter									
S6008-A36.128	679		646		39		U		U
S6008-A37.129	675		636		39		U		U
S6008-A38.134	680		640		39		U		U
S6008-A45.136	699		647		33		U		U
S6008-A46.137	697		662		23	J	U		U
S6008-A47.153	706		671		25		U		U
Mean	689		650		33		U		U
% RSD	2		2		22				
ISVS without filter									
S6009-A54.167	720		685		9	J	U		U
S6009-A55.169	721		679		14	J	U		U
S6009-A56.170	729		693		7	J	U		U
S6009-A57.229	728		691		4	J	U		U
S6009-A58.230	721		695		5	J	U		U
S6009-A59.248	733		697		5	J	U		U
Mean	725		690		7.5	J	U		U
% RSD	1		1		49				
Grand Mean	719		681		20	J	U		U
% RSD	3		3		71				

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.10. Tank C-107 Total Nonmethane Hydrocarbon Vapors

	Total Nonmethane Hydrocarbons (mg/m³)
VSS	
S6001-A03.302	3.5
S6001-A04.303	4.1
S6001-A15.304	3.8
S6001-A16.305	3.5
S6001-A27.306	3.3
S6001-A28.307	3.4
Mean	3.6
% RSD	8
ISVS with filter	
S6002-A36.310	4.5
S6002-A37.311	4.7
S6002-A38.312	4.6
S6002-A45.313	3.4
S6002-A46.314	3.8
S6002-A47.315	3.9
Mean	4.2
% RSD	13
ISVS without filter	
S6003-A54.317	7.0
S6003-A55.318	6.9
S6003-A56.319	5.2
S6003-A57.320	7.0
S6003-A58.321	6.8
S6003-A59.322	6.4
Mean	6.6
% RSD	11
Grand Mean	4.8
% RSD	30

Table A.11. Tank BY-108 Total Nonmethane Hydrocarbon Vapors

	Total Nonmethane Hydrocarbons (mg/m³)
VSS	
S6004-A03.029	220
S6004-A04.050	230
S6004-A15.054	220
S6004-A16.055	220
S6004-A27.067	220
S6004-A28.080	220
Mean	222
% RSD	2
ISVS with filter	
S6005-A36.114	180
S6005-A37.116	190
S6005-A38.138	190
S6005-A45.143	180
S6005-A46.145	180
S6005-A47.154	200
Mean	187
% RSD	4
ISVS without filter	
S6006-A54.182	200
S6006-A55.208	200
S6006-A56.211	200
S6006-A57.228	200
S6006-A58.323	210
S6006-A59.324	210
Mean	203
% RSD	3
Grand Mean	204
% RSD	8

Table A.12. Tank S-102 Total Nonmethane Hydrocarbon Vapors

	Total Nonmethane Hydrocarbons (mg/m³)
VSS	
S6007-A03.082	15
S6007-A04.083	16
S6007-A15.084	16
S6007-A16.097	15
S6007-A27.108	17
S6007-A28.120	17
S6007-A87.086	16
S6007-A88.089	16
Mean	16.1
% RSD	4
ISVS with filter	
S6008-A36.128	15
S6008-A37.129	16
S6008-A38.134	15
S6008-A45.136	18
S6008-A46.137	16
S6008-A47.153	15
Mean	15.9
% RSD	7
ISVS without filter	
S6009-A54.167	18
S6009-A55.169	20
S6009-A56.170	17
S6009-A57.229	16
S6009-A58.230	17
S6009-A59.248	17
Mean	17.6
% RSD	9
Grand Mean	16.5
% RSD	8

Table A.13. Tank C-107 Organic Vapors in SUMMA™ Canisters

	Methanol (ppbv)		Ethanol (ppbv)		1-Propanol (ppbv)		1-Butanol (ppbv)		Acetonitrile (ppbv)		Propanenitrile (ppbv)	
VSS												
S6001-A03.302	1127		66		8.6		5.0		889		117	
S6001-A04.303	887		47		7.2		4.4	J	695		119	
S6001-A15.304	1205		73		11		6.3		976		124	
S6001-A16.305	1233		67		9.1		6.3		879		117	
S6001-A27.306	1130		66		8.8		5.4		967		124	
S6001-A28.307	1296		77		10		4.8	J	1025		126	
Mean	1146		66		9.0		5.4		905		121	
% RSD	12		16		13		15		13		3	
ISVS with filter												
S6002-A36.310	1037		67		8.5		23		802		106	
S6002-A37.311	1274		92		12		47		929		117	
S6002-A38.312	1151		86		14		29		754		111	
S6002-A45.313	1220		78		12		10		878		115	
S6002-A46.314	1346		91		13		13		932		117	
S6002-A47.315	1050		73		13		13		796		110	
Mean	1179		81		12		23		848		113	
% RSD	10		12		16		62		9		4	
ISVS without filter												
S6003-A54.317	1189		102		14		80		881		118	
S6003-A55.318	943		79		13		89		639		104	
S6003-A56.319	1227		101		12		37		910		116	
S6003-A57.320	1360		111		15		60		983		126	
S6003-A58.321	1351		111		14		78		973		120	
S6003-A59.322	1319		110		14		97		1080		140	
Mean	1231		102		14		74		911		121	
% RSD	13		12		7.2		30		16		10	
Grand Mean	1186		83		12		34		888		118	
% RSD	12		22		20		97		13		7	

J = Result between IDL and estimated quantitation limit.

Table A.13. (contd) Tank C-107 Organic Vapors in SUMMA™ Canisters

	Acetone (ppbv)		2-Butanone (ppbv)		Tetrahydrofuran (ppbv)		Hexane (ppbv)		Nonane (ppbv)	
VSS										
S6001-A03.302	603		27			U	0.7	J		U
S6001-A04.303	469		27			U	0.8	J	0.4	J
S6001-A15.304	683		29			U		U		U
S6001-A16.305	600		27			U	0.7	J		U
S6001-A27.306	661		28			U		U		U
S6001-A28.307	688		28			U	0.7	J		U
Mean	617		28			U	0.7	J	0.4	J
% RSD	13		3				7			
ISVS with filter										
S6002-A36.310	559		26			U	2.7	J	0.4	J
S6002-A37.311	628		25			U	3.4	J	0.5	J
S6002-A38.312	510		25			U	3.1	J	0.5	J
S6002-A45.313	600		27			U	0.7	J	0.4	J
S6002-A46.314	640		27			U	0.9	J	0.4	J
S6002-A47.315	536		25			U	1.0	J		U
Mean	579		26			U	1.9	J	0.4	J
% RSD	9		3				62		18	
ISVS without filter										
S6003-A54.317	590		27			U	8.5			U
S6003-A55.318	434		25			U	7.4			U
S6003-A56.319	634		30			U	5.1			U
S6003-A57.320	671		29			U	8.1			U
S6003-A58.321	673		30			U	8.1			U
S6003-A59.322	726		32			U	7.6			U
Mean	621		29			U	7.5			U
% RSD	16		8				17			
Grand Mean	606		27			U	3.7		0.4	J
% RSD	13		7				86		16	

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.13. (contd) Tank C-107 Organic Vapors in SUMMA™ Canisters

	Decane (ppbv)		Undecane (ppbv)		Dodecane (ppbv)		Tridecane (ppbv)		Tetradecane (ppbv)	
VSS										
S6001-A03.302	0.5	J	4.3		5.7	J	3.5	J		U
S6001-A04.303	0.8	J	5.1		5.9	J	4.6			U
S6001-A15.304	0.8	J	6.3		8.3		6.5			U
S6001-A16.305	0.5	J	4.2		5.6	J	3.1	J		U
S6001-A27.306	0.7	J	5.7		7.3		5.5			U
S6001-A28.307	0.5	J	4.8		6.7		4.9			U
Mean	0.6	J	5.1		6.6	J	4.7	J		U
% RSD	20		16		16		27			
ISVS with filter										
S6002-A36.310	0.6	J	4.1		4.4	J	2.6	J		U
S6002-A37.311	0.8	J	4.6		5.4	J	3.2	J		U
S6002-A38.312	0.7	J	4.6		4.2	J	2.9	J		U
S6002-A45.313	0.6	J	4.5		5.1	J	3.0	J		U
S6002-A46.314	0.7	J	4.4		5.4	J	2.9	J		U
S6002-A47.315		U	4.2		4.5	J	3.2	J		U
Mean	0.7	J	4.4		4.8	J	3.0	J		U
% RSD	12		5		11		8			
ISVS without filter										
S6003-A54.317	0.8	J	5.2		5.5	J	3.2	J		U
S6003-A55.318	0.6	J	3.9			U	2.9	J		U
S6003-A56.319	0.6	J	3.9		3.7	J	2.4	J		U
S6003-A57.320	0.8	J	4.5		5.8	J	3.2	J		U
S6003-A58.321	0.8	J	4.7		5.4	J	2.6	J		U
S6003-A59.322	0.8	J	5.3		6.3	J	3.4	J		U
Mean	0.7	J	4.6		5.3	J	2.9	J		U
% RSD	13		14		18		13			
Grand Mean	0.7	J	4.7		5.6	J	3.5	J		U
% RSD	15		14		20		32			

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.14. Tank BY-108 Organic Vapors in SUMMA™ Canisters

	Methanol (ppbv)		Ethanol (ppbv)		1-Propanol (ppbv)		1-Butanol (ppbv)		Acetonitrile (ppbv)		Propanenitrile (ppbv)	
VSS												
S6004-A03.029	2137		1017		511		20425		147		8.6	J
S6004-A04.050	1827		1900		411		17087		113		4.1	J
S6004-A15.054	2201		1057		484		18873		116		4.8	J
S6004-A16.055	2070		979		471		22057		119		4.6	J
S6004-A27.067	2141		1010		467		19238		113		5.1	J
S6004-A28.080	2025		986	E	438		15728		180		4.0	J
Mean	2067		1158		464		18901		131		5.2	J
% RSD	6		31		8		12		21		33	
ISVS with filter												
S6005-A36.114	2032		948		405		16885		114		4.1	J
S6005-A37.116	1742		817		504		18607		126		5.4	J
S6005-A38.138	2126		1007		499		19096		127		5.5	J
S6005-A45.143	1990		929		435		16657		115		4.6	J
S6005-A46.145	2030		984		408		16934		137		3.8	J
S6005-A47.154	2103	E	1028		429		18177		137		3.5	J
Mean	2004		952		446		17726		126		4.5	J
% RSD	7		8		10		6		8		18	
ISVS without filter												
S6006-A54.182	1895		889		491		21106		127		5.7	J
S6006-A55.208	2287		1130		467		17378		122		4.7	J
S6006-A56.211	2012		952		500		21171		125		5.2	J
S6006-A57.228	1880		900	E	429		16110		242		4.2	J
S6006-A58.323	2208		1036		500		18252		124		5.3	J
S6006-A59.324	1971	E	904		467		18003		141		4.8	J
Mean	2042		969		476		18670		147		5.0	J
% RSD	8		10		6		11		32		11	
Grand Mean	2038		1026		462		18432		135		4.9	J
% RSD	7		22		8		10		23		23	

E = Result above upper calibration limit.

J = Result between IDL and estimated quantitation limit.

Table A.14. (contd) Tank BY-108 Organic Vapors in SUMMA™ Canisters

	Acetone (ppbv)		2-Butanone (ppbv)		Tetrahydrofuran (ppbv)		Hexane (ppbv)		Nonane (ppbv)	
VSS										
S6004-A03.029	2269		414		851		1141		85	
S6004-A04.050	4255		130		651		1048		71	
S6004-A15.054	1923		343		781		1030		76	
S6004-A16.055	3997		377		791		1133		76	
S6004-A27.067	1873		344		765		1026		74	
S6004-A28.080	2022		111		646		1047		72	
Mean	2723		286		747		1071		76	
% RSD	40		46		11		5		7	
ISVS with filter										
S6005-A36.114	2309		311		711		1109		66	
S6005-A37.116	1894		375		788		951		74	
S6005-A38.138	1812		356		772		991		72	
S6005-A45.143	1864		318		742		1002		67	
S6005-A46.145	2017		107		588		1121		62	
S6005-A47.154	2035		105		607		1062		67	
Mean	1989		262		701		1039		68	
% RSD	9		47		12		7		7	
ISVS without filter										
S6006-A54.182	2133		390		807		1083		77	
S6006-A55.208	2193		356		766		1104		74	
S6006-A56.211	2004		392		809		1136		77	
S6006-A57.228	1817		122		664		1045		68	
S6006-A58.323	1849		352		761		1021		73	
S6006-A59.324	4610		134		688		1007		80	
Mean	2434		291		749		1066		75	
% RSD	44		44		8		5		6	
Grand Mean	2382		280		732		1059		73	
% RSD	38		43		10		5		8	

E = Result above upper calibration limit.

Table A.14. (contd) Tank BY-108 Organic Vapors in SUMMA™ Canisters

	Decane (ppbv)		Undecane (ppbv)		Dodecane (ppbv)		Tridecane (ppbv)		Tetradecane (ppbv)	
VSS										
S6004-A03.029	128		230		683		549		471	
S6004-A04.050	103		181		662		570		643	
S6004-A15.054	114		210		808		515		387	
S6004-A16.055	118		230		628		405		295	
S6004-A27.067	111		203		761		530		374	
S6004-A28.080	118		255		848	E	699		581	
Mean	115		218		732		545		459	
% RSD	7		12		12		17		29	
ISVS with filter										
S6005-A36.114	95		172		478		221		48	
S6005-A37.116	107		190		432		221		69	
S6005-A38.138	104		176		549		271		91	
S6005-A45.143	94		173		425		201		47	
S6005-A46.145	98		185		584	E	343		135	
S6005-A47.154	102		190		610		375		166	
Mean	100		181		513		272		93	
% RSD	5		5		15		26		52	
ISVS without filter										
S6006-A54.182	112		210		599		298		101	
S6006-A55.208	108		183		746		345		128	
S6006-A56.211	116		220		530		275		106	
S6006-A57.228	99		175		669		465		300	
S6006-A58.323	108		188		680		340		104	
S6006-A59.324	121		216		601	E	404		316	
Mean	111		199		637		354		176	
% RSD	7		9		12		20		59	
Grand Mean	109		199		627		390		242	
% RSD	9		12		19		36		77	

E = Result above upper calibration limit.

Table A.15. Tank S-102 Organic Vapors in SUMMA™ Canisters

	Methanol (ppbv)		Ethanol (ppbv)		1-Propanol (ppbv)		1-Butanol (ppbv)		Acetonitrile (ppbv)		Propanenitrile (ppbv)	
VSS												
S6007-A03.082	5242	E	4760	E	34		464		32		3.9	J
S6007-A04.083	6181	E	6154	E	33		394		40		3.5	J
S6007-A15.084	4772	E	5180	E	41		431		38		4.4	J
S6007-A16.097	4577	E	4146	E	33		425		56		3.7	J
S6007-A27.108	5629	E	5970	E	41		418		50		4.4	J
S6007-A28.120	5481	E	6457	E	41		434		40		4.2	J
S6007-A87.086	5790	E	5753	E	37		384		41		4.0	J
S6007-A88.089	5465	E	4958	E	37		455		49		3.8	J
Mean	5392	E	5422	E	37		426		43		4.0	J
% RSD	10		15		9		6		18		8	
ISVS with filter												
S6008-A36.128	6171	E	4403	E	42		386		47		4.4	J
S6008-A37.129	6138	E	5987	E	34		367		25		3.3	J
S6008-A38.134	6623	E	4892	E	46		478		32		4.2	J
S6008-A45.136	5381	E	6429	E	36		379		46		3.8	J
S6008-A46.137	4547	E	4203	E	38		450		36		3.3	J
S6008-A47.153	5012	E	4326	E	40		487		20		3.5	J
Mean	5645	E	5040	E	39		424		34		3.8	J
% RSD	14		19		10		13		32		12	
ISVS without filter												
S6009-A54.167	5190	E	4783	E	34		448		23		3.7	J
S6009-A55.169	4959	E	5984	E	45		511		33		3.9	J
S6009-A56.170	5780	E	6010	E	41		445		25		4.0	J
S6009-A57.229	6113	E	6117	E	41		420		34		4.2	J
S6009-A58.230	3677	E	3844	E	32		392		26		3.6	J
S6009-A59.248	6110	E	5830	E	38		411		23		4.0	J
Mean	5305	E	5428	E	39		438		27		3.9	J
% RSD	18		17		12		10		18		5	
Grand Mean	5442	E	5309	E	38		429		36		3.9	J
% RSD	13		16		10		9		29		9	

E = Result above upper calibration limit.

J = Result between IDL and estimated quantitation limit.

Table A.15. (contd) Tank S-102 Organic Vapors in SUMMA™ Canisters

	Acetone (ppbv)		2-Butanone (ppbv)		Tetrahydrofuran (ppbv)		Hexane (ppbv)		Nonane (ppbv)	
VSS										
S6007-A03.082	451		48		50		7.4		2.0	
S6007-A04.083	252		46		43		7.9		1.8	
S6007-A15.084	413		56		50		8.6		2.4	
S6007-A16.097	595		49		48		7.3		2.0	
S6007-A27.108	556		56		46		7.8		1.8	
S6007-A28.120	276		53		48		8.0		2.0	
S6007-A87.086	471		47		43		7.2		1.7	
S6007-A88.089	452		50		48		7.2		1.9	
Mean	433		51		47		7.7		1.9	
% RSD	28		8		6		7		11	
ISVS with filter										
S6008-A36.128	534		45		42		7.2		1.5	J
S6008-A37.129	213		44		39		10.0		1.4	J
S6008-A38.134	607		47		42		7.6		1.8	
S6008-A45.136	280		46		45		13.8		1.9	
S6008-A46.137	563		46		42		7.6		1.6	
S6008-A47.153	615		50		45		7.9		1.7	
Mean	469		46		43		9.0		1.7	
% RSD	38		5		5		28		11	
ISVS without filter										
S6009-A54.167	451		50		47		13		1.8	
S6009-A55.169	310		51		47		13		2.0	
S6009-A56.170	489		54		47		13		2.0	
S6009-A57.229	540		84		46		11		1.9	
S6009-A58.230	597		59		46		9.8		1.8	
S6009-A59.248	293		50		46		10		1.8	
Mean	447		58		46		11		1.9	
% RSD	27		22		0.5		11		5	
Grand Mean	448		52		46		9		1.8	
% RSD	30		17		6		24		11	

J = Result between IDL and estimated quantitation limit.

Table A.15. (contd) Tank S-102 Organic Vapors in SUMMA™ Canisters

	Decane (ppbv)		Undecane (ppbv)		Dodecane (ppbv)		Tridecane (ppbv)		Tetradecane (ppbv)	
VSS										
S6007-A03.082	1.3	J	1.0	J	1.3	J	0.8	J		U
S6007-A04.083	1.2	J	0.8	J	1.2	J	0.7	J		U
S6007-A15.084	1.8	J	1.2	J	1.8	J	0.7	J		U
S6007-A16.097	1.3	J	1.0	J	1.3	J	0.9	J		U
S6007-A27.108	1.4	J		U	1.4	J	0.9	J		U
S6007-A28.120	1.5	J	1.0	J	1.5	J	1.1	J		U
S6007-A87.086	1.2	J	0.9	J	1.2	J	0.5	J		U
S6007-A88.089	1.3	J	0.8	J	1.3	J	0.9	J		U
Mean	1.3	J	0.9	J	1.3	J	0.8	J		U
% RSD	15		13		15		19			U
ISVS with filter										
S6008-A36.128	1.0	J	0.7	J	1.0	J	1.1	J		U
S6008-A37.129	0.9	J	0.7	J	0.9	J	0.7	J		U
S6008-A38.134	1.2	J	0.8	J	1.2	J	1.0	J		U
S6008-A45.136	1.4	J	0.9	J	1.4	J	0.9	J		U
S6008-A46.137	1.1	J	0.8	J	1.1	J	0.7	J		U
S6008-A47.153	1.2	J	0.8	J	1.2	J	0.8	J		U
Mean	1.1	J	0.8	J	1.1	J	0.9	J		U
% RSD	15		9		15		22			U
ISVS without filter										
S6009-A54.167	1.2	J	0.8	J	1.2	J	0.7	J		U
S6009-A55.169	1.4	J	1.0	J	1.4	J	0.9	J		U
S6009-A56.170	1.4	J	1.0	J	1.4	J	0.7	J		U
S6009-A57.229	1.3	J	0.9	J	1.3	J	0.5	J		U
S6009-A58.230	1.3	J	0.7	J	1.3	J	0.6	J		U
S6009-A59.248	1.3	J	0.8	J	1.3	J		U		U
Mean	1.3	J	0.8	J	1.3	J	0.7	J		U
% RSD	7		12		7		25			U
Grand Mean	1.3	J	0.9	J	1.3	J	0.8	J		U
% RSD	14		15		14		22			U

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.16. Tank C-107 Organic Vapors in Triple Sorbent Traps

	Methanol (ppbv)		Ethanol (ppbv)		1-Propanol (ppbv)		1-Butanol (ppbv)		Acetonitrile (ppbv)		Propanenitrile (ppbv)	
VSS												
S6001-A05.773	852		152		23		10.4	J	519		90	
S6001-A06.774	946		169		16	J	5.9	J	501		94	
S6001-A07.775	2159	E	301		26		7.7	J	745		105	
S6001-A08.776	1616		206		14	J	7.3	J	645		91	
S6001-A09.777	1363		237		15	J	6.8	J	669		99	
S6001-A10.778	1603		232		15	J	7.8	J	656		94	
Mean	1423		216		18	J	7.7	J	623		96	
% RSD	34		25		28		20		15		6	
ISVS with filter												
S6002-A39.784	1501		240		17	J	180		490		68	
S6002-A40.785	2026	E	376		24		116		651		88	
S6002-A41.786	1795		363		20	J	175		578		83	
S6002-A48.788	1567		275		25		50		558		82	
S6002-A49.789	1743		318		21	J	85		651		94	
S6002-A50.790	1347		168		26		67		656		95	
Mean	1663		290		22	J	112		597		85	
% RSD	15		27		15		49		11		12	
ISVS without filter												
S6003-A60.791	1558		371		25		258		496		71	
S6003-A62.794	1073		311		21		208		480		76	
S6003-A63.796	1141		329		25		339		470		86	
S6003-A64.797	1186		308		20	J	463		478		71	
S6003-A65.798	1341		397		23		503		488		80	
S6003-A66.792	1139		85		21	J	232		515		75	
Mean	1240		300		23		334		488		76	
% RSD	15		37		9.7		37		3		7	
Grand Mean	1442		269		21		151		569		86	
% RSD	25		33		19		105		15		12	

J = Result between IDL and estimated quantitation limit.

E = Result is above upper calibration limit.

Table A.16. (contd) Tank C-107 Organic Vapors in Triple Sorbent Traps

	Acetone (ppbv)		2-Butanone (ppbv)		Tetrahydrofuran (ppbv)		Hexane (ppbv)		Nonane (ppbv)	
VSS										
S6001-A05.773	262		20			U	1.1	J		U
S6001-A06.774	277		22			U	1.2	J		U
S6001-A07.775	353		24			U	0.8	J	0.2	J
S6001-A08.776	260		20			U	0.6	J	0.4	J
S6001-A09.777	335		20			U	0.8	J		U
S6001-A10.778	283		18			U	0.8	J		U
Mean	295		21			U	0.9	J	0.3	J
% RSD	13		11				26		35	
ISVS with filter										
S6002-A39.784	174		21			U	43			U
S6002-A40.785	207		21			U	35		0.5	J
S6002-A41.786	236		27			U	38			U
S6002-A48.788	233		24			U	23		0.7	J
S6002-A49.789	231		20			U	35			U
S6002-A50.790	249		29			U	22		0.5	J
Mean	222		24			U	33		0.6	J
% RSD	12		15				26		18	
ISVS without filter										
S6003-A60.791	199		39			U	137		1.1	J
S6003-A62.794	183		27			U	110			U
S6003-A63-796	207		37			U	79			U
S6003-A64.797	225		44			U	136			U
S6003-A65.798	204		48			U	137			U
S6003-A66.792	195		35			U	112		1.0	J
Mean	202		38			U	119		1.1	J
% RSD	7		19				19		6	
Grand Mean	240		28			U	51		0.6	J
% RSD	20		33				104		50	

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.16. (contd) Tank C-107 Organic Vapors in Triple Sorbent Traps

	Decane (ppbv)		Undecane (ppbv)		Dodecane (ppbv)		Tridecane (ppbv)		Tetradecane (ppbv)		Tributyl phosphate (ppbv)	
VSS												
S6001-A05.773	1.2	J	5.7	J	6.3	J	5.6	J	5.7	J		U
S6001-A06.774	1.4	J	5.7	J	6.4	J	6.0	J	6.2	J		U
S6001-A07.775	0.7	J	4.5	J	4.5	J		U		U		U
S6001-A08.776	0.9	J	4.3	J	4.3	J	3.1	J	0.8	J		U
S6001-A09.777		U		U		U		U		U		U
S6001-A10.778	1.0	J	4.8	J	5.2	J	3.8	J	0.8	J		U
Mean	1.0	J	4.3	J	5.4	J	4.6	J	3.4	J		U
% RSD	26		45		18		30		87			
ISVS with filter												
S6002-A39.784	0.6	J	2.5	J	2.8	J	2.9	J	0.7	J		U
S6002-A40.785	1.0	J	4.3	J	4.9	J		U		U		U
S6002-A41.786	0.9	J	3.3	J	3.8	J	4.5	J	1.1	J		U
S6002-A48.788	1.2	J	3.6	J	4.0	J	5.6	J	1.6	J		U
S6002-A49.789	1.0	J	4.1	J	4.6	J	5.2	J	1.4	J		U
S6002-A50.790	0.4	J	3.3	J	3.7	J	4.6	J	1.1	J		U
Mean	0.8	J	3.5	J	4.0	J	4.6	J	1.2	J		U
% RSD	39		19		19		23		29			
ISVS without filter												
S6003-A60.791	1.7	J	5.3	J	5.4	J		U		U		U
S6003-A62.794	1.4	J	5.4	J	5.6	J		U		U		U
S6003-A63.796	1.0	J	4.3	J	4.5	J	3.2	J	0.4	J		U
S6003-A64.797	0.8	J	4.8	J	4.8	J	3.7	J	0.7	J		U
S6003-A65.798	1.4	J	4.9	J	5.0	J	3.7	J	0.7	J		U
S6003-A66.792	0.1	J	5.0	J	5.4	J	3.9	J	0.6	J		U
Mean	1.0	J	5.0	J	5.1	J	3.6	J	0.6	J		U
% RSD	53		8		8.2		8		24			
Grand Mean	1.0	J	4.2	J	4.8	J	4.3	J	1.7	J		U
% RSD	41		30		19		24		115			

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.17. Tank BY-108 Organic Vapors in Triple Sorbent Traps

	Methanol (ppbv)		Ethanol (ppbv)		1-Propanol (ppbv)		1-Butanol (ppbv)		Acetonitrile (ppbv)		Propanenitrile (ppbv)	
VSS												
S6004-A05.707	2790	E	2654	E	456		13991	E	232		17	
S6004-A06.708	3279	E	2815	E	467		12666	E	242		18	
S6004-A07.709	2984	E	2045	E	434		11726	E	261		18	
S6004-A08.710	2586	E	2369	E	488		13056	E	205		17	
S6004-A09.711	2781	E	1531		335		13258	E	50		0.8 ^(a)	U
S6004-A10.715	1680		2147	E	423		12439	E	190		13	
Mean	2683	E	2260	E	434		12856	E	197		14	
% RSD	20		20		12		6		39		48	
ISVS with filter												
S6005-A39.731	545	S	298	S	18	S	1230	S	28	S		S
S6005-A40.732	2025	E	1705		407		12169	E	274		17	
S6005-A41.733	3683	E	2537	E	401		9994	E	321		20	
S6005-A48.734	3780	E	3144	E	500		13365	E	272		15	
S6005-A49.738	3261	E	3184	E	468		12992	E	239		16	
S6005-A50.741	1504		1184		293		10621	E	216		17	
Mean	2851	E	2351	E	414		11828	E	264		17	
% RSD	36		38		19		12		15		11	
ISVS without filter												
S6006-A61.745	738		925		157		7161	E	146		6	
S6006-A62.754	2994	E	2487	E	426		11015	E	258		22	
S6006-A63.755	1973	E	2342	E	366		10811	E	121		8	
S6006-A65.758	2515	E	3122	E	409		10602	E	256		15	
Mean	2055	E	2219	E	340		9897	E	195		13	
% RSD	47		42		37		19		37		58	
Grand Mean	2571	E	2279	E	402		11724	E	219		15	
% RSD	33		31		22		15		32		38	

J = Result between IDL and estimated quantitation limit.

E = Result is above upper calibration limit.

U = Result below IDL.

S = Value is suspect and is not included in mean.

(a) Detection limit included in the statistical analysis.

Table A.17. (contd) Tank BY-108 Organic Vapors in Triple Sorbent Traps

	Acetone (ppbv)		2-Butanone (ppbv)		Tetrahydrofuran (ppbv)		Hexane (ppbv)		Nonane (ppbv)	
VSS										
S6004-A05.707	2032	E	300		780		1158	E	83	
S6004-A06.708	2068	E	309		801		1135	E	85	
S6004-A07.709	2038	E	278		695		1111	E	87	
S6004-A08.710	2336	E	324		829		1130	E	86	
S6004-A09.711	1663	E	238		545		794		63	
S6004-A10.715	2079	E	326		801		1166	E	88	
Mean	2036	E	296		742		1082	E	82	
% RSD	11		11		14		13		11	
ISVS with filter										
S6005-A39.731	166	S	28	S	32	S	124	S	6	S
S6005-A40.732	2099	E	314		802		1220	E	77	
S6005-A41.733	1907	E	277		671		984		69	
S6005-A48.734	2056	E	402		741		1213	E	77	
S6005-A49.738	2103	E	408		711		1213	E	65	
S6005-A50.741	2342	E	344		718		1086	E	71	
Mean	2101	E	349		729		1143	E	72	
% RSD	38		40		7		37		38	
ISVS without filter										
S6006-A61.745	1379		171		385		1030	E	39	
S6006-A62.754	2270	E	324		753		1310	E	87	
S6006-A63.755	1535		200		567		1136	E	62	
S6006-A65.758	2215	E	293		671		1371	E	95	
Mean	1850	E	247		594		1212	E	71	
% RSD	25		30		27		13		36	
Grand Mean	2008	E	301		698		1137	E	76	
% RSD	14		21		17		12		19	

E = Result above upper calibration limit.

S = Value is suspect and is not included in mean.

Table A.17. (contd) Tank BY-108 Organic Vapors in Triple Sorbent Traps

	Decane (ppbv)		Undecane (ppbv)		Dodecane (ppbv)		Tridecane (ppbv)		Tetradecane (ppbv)		Tributyl phosphate (ppbv)	
VSS												
S6004-A05.707	103		266		640	E	614	E	356	E		U
S6004-A06.708	101		277		667	E	636	E	411	E		U
S6004-A07.709	110		242		515	E	545	E	769	E		U
S6004-A08.710	107		279		708	E	756	E	428	E		U
S6004-A09.711	76		187		487	E	529	E	288	E		U
S6004-A10.715	106		273		656	E	623	E	372	E		U
Mean	101		254		612	E	617	E	437	E		U
% RSD	13		14		15		13		39			
ISVS with filter												
S6005-A39.731	7	S	14	S	27	S	20	S	6	S		U
S6005-A40.732	85		197		479		488	E	305	E		U
S6005-A41.733	78		201		474		468	E	331	E		U
S6005-A48.734	85		191		460		432	E	230			U
S6005-A49.738	66		131		312		296		156			U
S6005-A50.741	79		190		465		495	E	285	E		U
Mean	79		182		438		436	E	261	E		U
% RSD	10		16		16		19		27			
ISVS without filter												
S6006-A61.745	48		116		247		204		91			U
S6006-A62.754	106		272		644	E	666	E	386	E		U
S6006-A63.755	73		195		475		460	E	294	E		U
S6006-A65.758	117		294		636	E	580	E	359	E		U
Mean	86		219		500	E	477	E	283	E		U
% RSD	37		37		37		42		47			
Grand Mean	89		221		524	E	519	E	337	E		U
% RSD	22		25		25		27		45			

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

E = Result above upper calibration limit.

S = Value is suspect and is not included in mean.

Table A.18. Tank S-102 Organic Vapors in Triple Sorbent Traps

	Methanol (ppbv)		Ethanol (ppbv)		1-Propanol (ppbv)		1-Butanol (ppbv)		Acetonitrile (ppbv)		Propanenitrile (ppbv)	
VSS												
S6007 A05.806	3918	E	12216	E	59		615		50		5.0	J
S6007 A06.807	5859	E	16898	E	56		610		84		5.1	J
S6007 A07.808	4236	E	13961	E	53		564		65		5.0	J
S6007 A08.809	4984	E	14064	E	42		636		68		5.3	J
S6007 A09.810	5104	E	14754	E	60		642		62		5.4	J
S6007 A10.811	5309	E	14858	E	58		618		61		5.2	J
Mean	4902	E	14458	E	55		614		65		5.2	J
% RSD	15		11		12		4		17		3	
ISVS with filter												
S6008 A39.817	4323	E	13006	E	54		605		56		5.0	J
S6008 A40.818	4247	E	10454	E	34		456		68		4.3	J
S6008 A41.819	3127	E	12244	E	50		545		65		5.2	J
S6008 A48.821	2900	E	8494	E	58		477		62		4.4	J
S6008 A49.822	4442	E	12533	E	48		513		62		5.0	J
S6008 A50.823	2573	E	8602	E	46		462		48		3.8	J
Mean	3602	E	10889	E	48		510		60		4.6	J
% RSD	23		18		17		11		12		12	
ISVS without filter												
S6009 A61.828	3767	E	14271	E	70		941		104		6.0	J
S6009 A62.830	5460	E	13597	E	63		981		93		5.6	J
S6009 A63.831	4882	E	12817	E	60		919		85		5.3	J
S6009 A64.832	4352	E	15631	E	48		828		80		5.6	J
S6009 A65.833	4299	E	13156	E	51		867		85		5.6	J
Mean	4552	E	13894	E	58		907		89		5.6	J
% RSD	14		8		15.2		7		11		4	
Grand Mean	4340	E	13033	E	54		664		70		5.1	J
% RSD	21		17		16		26		22		11	

E = Result above upper calibration limit.

J = Result between IDL and estimated quantitation limit.

Table A.18. (contd) Tank S-102 Organic Vapors in Triple Sorbent Traps

	Acetone (ppbv)		2-Butanone (ppbv)		Tetrahydrofuran (ppbv)		Hexane (ppbv)		Nonane (ppbv)	
VSS										
S6007 A05.806	239		58		52		9		3.1	
S6007 A06.807	271		58		52		9		3.1	
S6007 A07.808	261		64		53		10		3.3	
S6007 A08.809	260		64		53		9		3.3	
S6007 A09.810	260		57		54		9		3.2	
S6007 A10.811	237		55		53		8		3.0	
Mean	255		59		53		9		3.2	
% RSD	5		7		1		5		4	
ISVS with filter										
S6008 A39.817	241		53		49		126		2.9	
S6008 A40.818	236		43		41		123		3.1	
S6008 A41.819	261		62		52		110		3.0	
S6008 A48.821	215		45		42		73		3.0	
S6008 A49.822	248		51		45		74		3.0	
S6008 A50.823	219		47		40		61		2.7	
Mean	237		50		45		95		3.0	
% RSD	7		14		11		30		5	
ISVS without filter										
S6009 A61.828	356		63		56		170		4.0	
S6009 A62.830	310		60		51		191		3.8	
S6009 A63.831	286		54		49		185		3.4	
S6009 A64.832	320		62		52		154		3.7	
S6009 A65.833	303		66		54		162		3.8	
Mean	315		61		52		172		3.7	
% RSD	8		7		5		9		6	
Grand Mean	266		57		50		87		3.3	
% RSD	14		12		10		80		11	

Table A.18. (contd) Tank S-102 Organic Vapors in Triple Sorbent Traps

	Decane (ppbv)		Undecane (ppbv)		Dodecane (ppbv)		Tridecane (ppbv)		Tetradecane (ppbv)		Tributyl phosphate (ppbv)	
VSS												
S6007 A05.806	2.5	J	1.6	J	1.6	J	2.2	J	1.6	J		U
S6007 A06.807	2.3	J	1.4	J	1.4	J	1.8	J	1.0	J		U
S6007 A07.808	2.5	J	1.5	J	1.7	J	2.1	J	1.6	J		U
S6007 A08.809	2.4	J	1.4	J	1.5	J	1.9	J	1.2	J		U
S6007 A09.810	2.6	J	1.4	J	1.6	J	2.1	J	1.6	J		U
S6007 A10.811	2.4	J	1.5	J	1.9	J	3.3	J	3.1	J		U
Mean	2.5	J	1.5	J	1.6	J	2.2	J	1.7	J		U
% RSD	4		6		11		26		46			
ISVS with filter												
S6008 A39.817	2.7	J	1.6	J	2.1	J	5.9		3.3	J		U
S6008 A40.818	2.4	J	1.7	J	1.6	J	2.3	J	1.0	J		U
S6008 A41.819	2.5	J	1.8	J	1.5	J	2.4	J	1.1	J		U
S6008 A48.821	2.7	J	1.9	J	1.6	J	2.9	J	1.4	J		U
S6008 A49.822	2.4	J	1.8	J	1.5	J	2.7	J	0.9	J		U
S6008 A50.823	2.2	J	1.6	J	1.3	J	2.4	J	1.0	J		U
Mean	2.5	J	1.7	J	1.6	J	3.1	J	1.5	J		U
% RSD	8		6		17		45		64			
ISVS without filter												
S6009 A61.828	4.1		3.4	J	3.4	J	2.9	J	1.6	J		U
S6009 A62.830	3.8	J	3.0	J	3.7	J	4.5	J	4.2	J		U
S6009 A63.831	3.5	J	2.5	J	3.6	J	3.0	J	2.4	J		U
S6009 A64.832	3.3	J	2.5	J	3.2	J	2.5	J	1.4	J		U
S6009 A65.833	3.4	J	2.8	J	3.5	J	2.7	J	1.7	J		U
Mean	3.6	J	2.8	J	3.5	J	3.1	J	2.3	J		U
% RSD	9		13	J	5.5		25		51			
Grand Mean	2.8	J	2.0	J	2.1	J	2.8	J	1.8	J		U
% RSD	20		31		42		37		54			

U = Result below IDL.

J = Result between IDL and estimated quantitation limit.

Table A.19. Tank C-107 Result Means and Flammability Notification Limits

Analyte	Device	VSS mean (ppmv)	ISVS (w/ filter) mean (ppmv)	ISVS (w/o filter) mean (ppmv)	LFL (ppmv)	% of LFL		
						VSS mean	ISVS (w/ filter) mean	ISVS (w/o filter) mean
Ammonia	Sorbent	76	73	72	150000	0.051	0.049	0.048
Hydrogen	SUMMA™	242	233	241	40000	0.605	0.582	0.602
Nitrous oxide	SUMMA™	62	60	62	n.a.	n.a.	n.a.	n.a.
Carbon Dioxide	SUMMA™	693	693	701	n.a.	n.a.	n.a.	n.a.
TNMHC Vapors (mg/m³)	SUMMA™	3.60	4.15	6.55	45000	0.008	0.009	0.015
Methanol	SUMMA™	1.1	1.2	1.2	60000	0.002	0.002	0.002
Methanol	TST	1.4	1.7	1.2	60000	0.002	0.003	0.002
Ethanol	SUMMA™	0.07	0.08	0.10	33000	0.000	0.000	0.000
Ethanol	TST	0.22	0.29	0.30	33000	0.001	0.001	0.001
1-Propanol	SUMMA™	0.009	0.012	0.014	22000	0.000	0.000	0.000
Acetonitrile	SUMMA™	0.91	0.85	0.91	30000	0.003	0.003	0.003
Acetonitrile	TST	0.62	0.60	0.49	30000	0.002	0.002	0.002
Propanenitrile	SUMMA™	0.12	0.11	0.12	31000	0.000	0.000	0.000
Propanenitrile	TST	0.10	0.09	0.09	31000	0.000	0.000	0.000
Acetone	SUMMA™	0.62	0.58	0.62	25000	0.002	0.002	0.002
Acetone	TST	0.29	0.22	0.20	25000	0.001	0.001	0.001
2-Butanone	SUMMA™	0.028	0.026	0.029	14000	0.000	0.000	0.000
2-Butanone	TST	0.021	0.024	0.038	14000	0.000	0.000	0.000
Undecane	SUMMA™	0.005	0.004	0.005	6800	0.000	0.000	0.000
Estimated Total % of LFL						0.61	0.59	0.62

n.a. = not applicable

Table A.20. Tank BY-108 Result Means and Flammability Notification Limits

Analyte	Device	VSS mean (ppmv)	ISVS (w/ filter) mean (ppmv)	ISVS (w/o filter) mean (ppmv)	LFL (ppmv)	% of LFL		
						VSS mean	ISVS (w/ filter) mean	ISVS (w/o filter) mean
Ammonia	Sorbent	801	787	770	150000	0.534	0.525	0.513
Water vapor	Sorbent	14.4	14.1	13.7	n.a.	n.a.	n.a.	n.a.
Hydrogen	SUMMA™	361	347	360	40000	0.903	0.866	0.899
Nitrous oxide	SUMMA™	470	447	461	n.a.	n.a.	n.a.	n.a.
Carbon Dioxide	SUMMA™	12	30	17	n.a.	n.a.	n.a.	n.a.
Methane	SUMMA™	15.2	15.5	16.2	50000	0.030	0.031	0.032
TNMHC Vapors (mg/m³)	SUMMA™	222	187	203	45000	0.493	0.415	0.452
Ethanol	SUMMA™	1.16	0.95	0.97	33000	0.004	0.003	0.003
1-Propanol	SUMMA™	0.46	0.45	0.48	22000	0.002	0.002	0.002
1-Propanol	TST	0.43	0.41	0.34	22000	0.002	0.002	0.002
1-Butanol	SUMMA™	18.9	17.7	18.7	14000	0.14	0.13	0.13
Acetonitrile	SUMMA™	0.13	0.13	0.15	30000	0.000	0.000	0.000
Acetonitrile	TST	0.20	0.26	0.20	30000	0.001	0.001	0.001
Propanenitrile	SUMMA™	0.005	0.005	0.005	31000	0.000	0.000	0.000
Propanenitrile	TST	0.017	0.017	0.013	31000	0.000	0.000	0.000
Acetone	SUMMA™	2.7	2.0	2.4	25000	0.011	0.008	0.010
2-Butanone	SUMMA™	0.29	0.26	0.29	14000	0.002	0.002	0.002
2-Butanone	TST	0.30	0.35	0.25	14000	0.002	0.002	0.002
Tetrahydrofuran	SUMMA™	0.75	0.70	0.75	20000	0.004	0.004	0.004
Tetrahydrofuran	TST	0.74	0.73	0.59	20000	0.004	0.004	0.003
Hexane	SUMMA™	1.07	1.04	1.07	12000	0.009	0.009	0.009
Nonane	SUMMA™	0.08	0.07	0.08	8500	0.001	0.001	0.001
Nonane	TST	0.08	0.07	0.07	8500	0.001	0.001	0.001
Decane	SUMMA™	0.12	0.10	0.11	7500	0.002	0.001	0.001
Decane	TST	0.10	0.08	0.09	7500	0.001	0.001	0.001
Undecane	SUMMA™	0.22	0.18	0.20	6800	0.003	0.003	0.003
Undecane	TST	0.25	0.18	0.22	6800	0.004	0.003	0.003
Dodecane	SUMMA™	0.73	0.51	0.64	6000	0.012	0.009	0.011
Tridecane	SUMMA™	0.54	0.27	0.35	5500	0.010	0.005	0.006
Tetradecane	SUMMA™	0.46	0.09	0.18	5000	0.009	0.002	0.004
Estimated Total % of LFL						1.43	1.31	1.38

n.a. = not applicable

Table A.21. Tank S-102 Result Means and Flammability Notification Limits

Analyte	Device	VSS mean (ppmv)	ISVS (w/ filter) mean (ppmv)	ISVS (w/o filter) mean (ppmv)	LFL (ppmv)	% of LFL		
						VSS mean	ISVS (w/ filter) mean	ISVS (w/o filter) mean
Ammonia	Sorbent	622	615	595	150000	0.415	0.410	0.397
Hydrogen	SUMMA™	737	689	725	40000	1.843	1.723	1.813
Nitrous oxide	SUMMA™	697	650	690	n.a.	n.a.	n.a.	n.a.
TNMHC Vapors (mg/m³)	SUMMA™	16.00	15.83	17.50	45000	0.036	0.035	0.039
1-Propanol	SUMMA™	0.037	0.039	0.039	22000	0.000	0.000	0.000
1-Propanol	TST	0.055	0.048	0.058	22000	0.000	0.000	0.000
Acetonitrile	SUMMA™	0.043	0.034	0.027	30000	0.000	0.000	0.000
Acetonitrile	TST	0.065	0.060	0.089	30000	0.000	0.000	0.000
Acetone	SUMMA™	0.43	0.47	0.45	25000	0.002	0.002	0.002
Acetone	TST	0.25	0.24	0.32	25000	0.001	0.001	0.001
2-Butanone	SUMMA™	0.051	0.046	0.058	14000	0.000	0.000	0.000
2-Butanone	TST	0.059	0.050	0.061	14000	0.000	0.000	0.000
Tetrahydrofuran	SUMMA™	0.047	0.043	0.046	20000	0.000	0.000	0.000
Tetrahydrofuran	TST	0.053	0.045	0.052	20000	0.000	0.000	0.000
Nonane	SUMMA™	0.0019	0.0017	0.0019	8500	0.000	0.000	0.000
Nonane	TST	0.0032	0.0030	0.0037	8500	0.000	0.000	0.000
Estimated Total % of LFL						1.88	1.76	1.85

n.a. = not applicable

Table A.22. Tank C-107 Result Means and Toxicological Notification Limits

Analyte	Device	VSS mean (ppmv)	ISVS (w/ filter) mean (ppmv)	ISVS (w/o filter) mean (ppmv)	IDLH (ppmv)	% of IDLH		
						VSS mean	ISVS (w/ filter) mean	ISVS (w/o filter) mean
Ammonia	Sorbent	76	73	72	300	25	24	24
Hydrogen	SUMMA™	242	233	241	n.a.	n.a.	n.a.	n.a.
Nitrous oxide	SUMMA™	62	60	62	n.a.	n.a.	n.a.	n.a.
Carbon Dioxide	SUMMA™	693	693	701	40000	1.7	1.7	1.8
TNMHC Vapors (mg/m3)	SUMMA™	3.60	4.15	6.55	n.a.	n.a.	n.a.	n.a.
Methanol	SUMMA™	1.1	1.2	1.2	6000	0.019	0.020	0.021
Methanol	TST	1.4	1.7	1.2	6000	0.024	0.028	0.021
Ethanol	SUMMA™	0.07	0.08	0.10	3300	0.002	0.002	0.003
Ethanol	TST	0.22	0.29	0.30	3300	0.007	0.009	0.009
1-Propanol	SUMMA™	0.01	0.01	0.01	800	0.001	0.002	0.002
Acetonitrile	SUMMA™	0.91	0.85	0.91	500	0.181	0.170	0.182
Acetonitrile	TST	0.62	0.60	0.49	500	0.125	0.119	0.098
Propanenitrile	SUMMA™	0.12	0.11	0.12	n.a.	n.a.	n.a.	n.a.
Propanenitrile	TST	0.10	0.09	0.09	n.a.	n.a.	n.a.	n.a.
Acetone	SUMMA™	0.62	0.58	0.62	2500	0.025	0.023	0.025
Acetone	TST	0.29	0.22	0.20	2500	0.012	0.009	0.008
2-Butanone	SUMMA™	0.028	0.026	0.029	3000	0.001	0.001	0.001
2-Butanone	TST	0.021	0.024	0.038	3000	0.001	0.001	0.001
Undecane	SUMMA™	0.005	0.004	0.005	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable

Table A.23. Tank BY-108 Result Means and Toxicological Notification Limits

Analyte	Device	VSS mean (ppmv)	ISVS (w/ filter) mean (ppmv)	ISVS (w/o filter) mean (ppmv)	IDLH (ppmv)	% of IDLH		
						VSS mean	ISVS (w/ filter) mean	ISVS (w/o filter) mean
Ammonia	Sorbent	801	787	770	300	267	262	257
Hydrogen	SUMMA™	361	347	360	n.a.	n.a.	n.a.	n.a.
Nitrous oxide	SUMMA™	470	447	461	n.a.	n.a.	n.a.	n.a.
Carbon Dioxide	SUMMA™	12	30	17	40000	n.a.	n.a.	n.a.
Methane	SUMMA™	15.2	15.5	16.2	n.a.	n.a.	n.a.	n.a.
TNMHC Vapor (mg/m³)	SUMMA™	222	187	203	n.a.	n.a.	n.a.	n.a.
Methanol	SUMMA™	2.07	2.00	2.04	6000	0.034	0.033	0.034
Ethanol	SUMMA™	1.16	0.95	0.97	3300	0.035	0.029	0.029
1-Propanol	SUMMA™	0.46	0.45	0.48	800	0.058	0.056	0.059
1-Propanol	TST	0.43	0.41	0.34	800	0.054	0.052	0.042
1-Butanol	SUMMA™	18.9	17.7	18.7	500	3.8	3.5	3.7
Acetonitrile	SUMMA™	0.13	0.13	0.15	500	0.026	0.025	0.029
Acetonitrile	TST	0.20	0.26	0.20	500	0.039	0.053	0.039
Propanenitrile	SUMMA™	0.005	0.005	0.005	n.a.	n.a.	n.a.	n.a.
Propanenitrile	TST	2.04	2.10	1.85	n.a.	n.a.	n.a.	n.a.
Acetone	SUMMA™	2.7	2.0	2.4	2500	0.109	0.080	0.097
2-Butanone	SUMMA™	0.29	0.26	0.29	3000	0.010	0.009	0.010
2-Butanone	TST	0.30	0.35	0.25	3000	0.01	0.01	0.01
Tetrahydrofuran	SUMMA™	0.75	0.70	0.75	2000	0.037	0.035	0.037
Tetrahydrofuran	TST	0.74	0.73	0.59	2000	0.037	0.036	0.030
Hexane	SUMMA™	1.07	1.04	1.07	1100	0.097	0.095	0.097
Nonane	SUMMA™	0.08	0.07	0.08	n.a.	n.a.	n.a.	n.a.
Nonane	TST	0.08	0.07	0.07	n.a.	n.a.	n.a.	n.a.
Decane	SUMMA™	0.12	0.10	0.11	n.a.	n.a.	n.a.	n.a.
Decane	TST	0.10	0.08	0.09	n.a.	n.a.	n.a.	n.a.
Undecane	SUMMA™	0.22	0.18	0.20	n.a.	n.a.	n.a.	n.a.
Undecane	TST	0.25	0.18	0.22	n.a.	n.a.	n.a.	n.a.
Dodecane	SUMMA™	0.73	0.51	0.64	n.a.	n.a.	n.a.	n.a.
Tridecane	SUMMA™	0.54	0.27	0.35	n.a.	n.a.	n.a.	n.a.
Tetradecane	SUMMA™	0.46	0.09	0.18	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable

Table A.24. Tank S-102 Result Means and Toxicological Notification Limits

Analyte	Device	VSS mean (ppmv)	ISVS (w/ filter) mean (ppmv)	ISVS (w/o filter) mean (ppmv)	IDLH (ppmv)	% of IDLH		
						VSS mean	ISVS (w/ filter) mean	ISVS (w/o filter) mean
Ammonia	Sorbent	622	615	595	300	207	205	198
Hydrogen	SUMMA™	737	689	725	n.a.	n.a.	n.a.	n.a.
Nitrous oxide	SUMMA™	697	650	690	n.a.	n.a.	n.a.	n.a.
TNMHC Vapors (mg/m³)	SUMMA™	16.00	15.83	17.50	n.a.	n.a.	n.a.	n.a.
1-Propanol	SUMMA™	0.037	0.039	0.039	800	0.005	0.005	0.005
1-Propanol	TST	0.055	0.048	0.058	800	0.007	0.006	0.007
Acetonitrile	SUMMA™	0.043	0.034	0.027	500	0.009	0.007	0.005
Acetonitrile	TST	0.065	0.060	0.089	500	0.013	0.012	0.018
Acetone	SUMMA™	0.43	0.47	0.45	2500	0.017	0.019	0.018
2-Butanone	TST	0.051	0.046	0.058	3000	0.002	0.002	0.002
2-Butanone	SUMMA™	0.059	0.050	0.061	3000	0.002	0.002	0.002
Acetone	TST	0.25	0.24	0.32	2500	0.010	0.009	0.013
Tetrahydrofuran	SUMMA™	0.047	0.043	0.046	2000	0.002	0.002	0.002
Tetrahydrofuran	TST	0.053	0.045	0.052	2000	0.003	0.002	0.003
Nonane	SUMMA™	0.0019	0.0017	0.0019	n.a.	n.a.	n.a.	n.a.
Nonane	TST	0.0032	0.0030	0.0037	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable

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